RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

VOL. V DECEMBER, 1925 No. 6

RADIOLOGIC CONSIDERATIONS OF GASTRO-DUODENAL ANATOMY AND PHYSIOLOGY [1]

By JUAN CUNHA, M.D., MONTEVIDEO, URUGUAY

FOREWORD

THERE are two groups of signs in gastro-duodenal radiology: the direct and the indirect. The first consist of permanent deformities—the niches in all their different manifestations, the defects of various shapes and appearances. When they are plainly evident, when they persist during one, two or more examinations, when one knows how to avoid the causes of error, these signs may be considered as pathognomonic, and they are sufficient, even in the face of all clinical data to the contrary, to make a positive diagnosis of ulcer or of cancer.

These signs are known to all radiologists and to all good clinicians and no more time need be devoted to them here. To-day, with the perfection of technic, we see them better and more often, but their recognition is still rare in comparison with the great number of gastro-duodenal patients whom we see for radiologic study, and in the great majority of these cases we have to fall back upon the indirect signs in order to make a diagnosis or to orient the clinician.

Since the beginning of gastric radiology a great many indirect signs have been described. To each one somebody has endeavored to attach considerable value; not one has escaped criticism and rigid testing. All are based upon the anatomy and physiology of the stomach and duodenum, and only through an exact knowledge of the latter can one put a proper interpretation and evaluation upon them.

We see these signs on the screen or in the radiogram, but we interpret them in relation to the anatomical structure of the organ and its physiologic behavior. In viewing the radiologic image of a stomach, we must see also projected upon it its anatomical architecture with the many and varied changes of form imposed upon it by its physiologic functioning. The radiologist who wishes to do worth-while work has greater need of anatomical knowledge than the surgeon himself. The wayfarer by night must know the country more intimately than he who travels in broad daylight. Through an insufficient recognition of these facts many authors have been led into attributing to indirect signs a value they do not possess and to fall into lamentable contradictions which obscure and complicate the problems of gastro-duodenal pathology as seen on the fluoroscopic screen. One must construct a mental combination of the radiologic and the psychic image for a careful study of gastro-duodenal anatomy and physiology.

* * * * * * * * * * *

Prof. Krehl in his book on Pathological Physiology says: "The form, size and position of the stomach depend upon the state of the musculature and upon the excitability of the nerves, upon its content, and upon its emptying time as well as upon

[1] From the Surgical Clinic of Professor Navarro, Montevideo, Uruguay.

the state of its supports and of the neighboring organs."

This concise statement of the great German physiologist includes the whole program of X-ray investigation of the stomach. It is a vast and complex program, but one must know thoroughly each and every one of its phases if he wishes to interpret well and take full advantage of the radiologic study.

The first item of the program includes the anatomy of the organ, its means of fixation, its relations to neighboring organs, the anatomical structure, its diverse layers and nerve plexuses. It is necessary to do careful anatomical dissections on the cadaver and to associate these dissections with the behavior of the living organ as seen with the radioscopic screen. This is the way to study radiologic anatomy—upon the living. The radiologic anatomy of the cadaver has no value.

The stomach, according to the anatomists, is well attached above by its continuity with the esophagus fixed at the diaphragmatic opening and by the gastrophrenic, gastrosplenic and gastrocolic ligaments. This is all very well for the cadaver with its abdomen opened, but it is false for the living individual with intact abdominal wall. In my opinion, the best means of fixation of the gastric dome is not supplied by its peritoneal ligaments but by its cohesion to the diaphragm; the two layers of tissue, gastric fundus and left diaphragm can not be separated unless one interposes a layer of gas or some other organ. The left diaphragm imposes its shape upon the gastric dome; when it is not full of liquid, it is full of gas. The diaphragm works upon it as an aspirating pump. Barometric equilibrium must be established between the two sides of the double gastro-diaphragmatic partition. This causes the formation of the gastric air pocket seen constantly on the screen examination of the stomach. The diaphragm in its deep excursions carries with it the walls of the fundus and the distention of the latter sucks air from the esophagus, or the patient swallows air to re-establish equilibrium. The air pocket of the stomach is a physiologic phenomenon produced by a purely physical mechanism. Recognition of this adaptation and cohesion of the gastric dome to the phrenic cupola, by the action of physical laws, which some authors forget, has, in my opinion, great significance for both radiologist and clinician.

The physiologists, like the anatomists, attribute the marked fixity of the dome and the great rarity of its ptosis to the ligaments and to its continuity with the esophagus. I understand that this does not withstand a severe criticism. The gastrophrenic ligament is badly located to carry out any duty as a support; it is posterior, not superior; it fixes the upper part of the posterior aspect, but not the dome. The gastrosplenic and gastrocolic ligaments are lax and elastic, and, moreover, they unite with movable organs; ptosis of the spleen and especially of the splenic flexure of the colon are common, and yet the greater curvature does not accompany them in their descent. The esophagus fixes very well the upper part of the lesser curvature but it cannot prevent separation between the fundus and the cupola; the cardia is situated lower than the dome and the rather variable length of the abdominal portion of the esophagus influences very little the position of the dome.

The pull exercised by organs situated below the stomach acts upon the body and the lower part of this organ, but not upon its higher parts. Whether the transverse colon is above the umbilicus or below the pubes, the dome of the stomach is always in contact with the diaphragm. On the screen we frequently see ptosis of the mid-portion of the stomach, ptosis of the pylorus and even the cardia, but never of the dome. For my part, I never have seen descent of the dome in relation to the diaphragm, total gastric ptosis. For this to occur certain special conditions must be fulfilled: either the diaphragm descends, which would be diaphragmatic ptosis; or gas enters the peritoneal cavity, the pneumoperitoneum

separating the stomach from the diaphragm and pushing it downward and toward the midline, or some neighboring organ interferes more than normally. The left flexure of the colon most frequently realizes this last condition; when it is very full of gas, it is also sucked up by the diaphragm and its diaphragmatic relations are much more extensive than anatomy teaches. We often see radioscopically a big air pocket in the colon outside of the stomach, either in front of or behind it, displacing it inward, backward and downward.

All these findings have their importance for correct interpretation of the radiologic images of the stomach.

Leaving for the moment the physiologic rôle of the gastric air pocket, we may record the following conclusions:

1. The dome of the stomach is maintained always high and distended by its intimate contact with the diaphragm, and the two are held united by the physical laws of pressure equilibrium which explain the formation of the air pocket.

2. The form of the gastric dome depends upon the form and condition of the diaphragm and of the splenic flexure of the colon; and when one examines the stomach, he must also examine the thorax, the diaphragm, its degree of mobility, the condition of the pleural sac and the left colic flexure.

* * * * * * * * * *

As described in the anatomies, the method of fixation of the middle and lower parts of the stomach is more in accord with clinical and radiologic observation.

The lesser omentum fixes the lesser curvature to the liver and in spite of its great variability and laxity exerts always a definite influence on the form and position of the curvature. Its cardiac and duodenal ends are stronger, and efficiently fix these parts of the organ; but its middle part, weak, stretched out, extensible, allows great excursion to the middle part of the lesser curvature.

The vessels, fortunately for them, play no part as supports, in spite of the contrary opinion of the anatomists.

The pylorus is in a measure fixed by its continuity with the duodenum. The first portion of the latter is movable, but its angle is fairly well fixed by the right border of the lesser omentum and by the parietal peritoneum which attaches the pars descendens to the posterior wall. When the pylorus descends, carried downward by the weight of the full stomach, it remains hung from the duodenal angle by the first portion, stretching it and giving it an almost vertical direction. This disposition of the pylorus and first part of the duodenum is that seen most often by us when we examine normal individuals in the erect position, the stomach filled by an opaque meal, and should be considered as normal in radiology. In my conception, Rieder is right. The normal form of the stomach, as seen by the radiologist, that is, filled with opaque emulsion and observed standing, is the hook-shaped stomach of Rieder. The steer-horn type, described by Holzknecht as normal, we do not see except in cases of marked hypertony or with lesser curvature adhesions, or in case of a transverse colon short or distended and lifted up by gases. We shall see later that the structure of the gastric walls supports Rieder's idea.

I conclude, then, that the normal form of the stomach, radiologically speaking, is that of a "J" hung by its ends from the cupola of the diaphragm and from the duodenal angle.

In this form the pylorus, or better the "pyloric zone" of the radiologists, has a nearly horizontal direction, corresponding in position to the body of the third lumbar vertebra. The pylorus is in front of the vertebral body, the duodenal angle at one side of it, in a plane somewhat posterior. The direction of the radiologic "duodenal bulb" is almost vertical when seen anteroposteriorly, but in reality it is slightly oblique from above down, from behind forward, and from without inward. We shall

see further the importance of all this in relation to gastro-duodenal physiology.

I lay some stress upon these radiological data, apparently contradictory to accepted notions, because I am convinced that when we succeed in throwing off many of the old anatomical ideas learned on the cadaver, we shall all the better understand the physiology and anatomy of the living.

The form and position of the stomach depend largely on a neighboring organ, the transverse colon.

I would compare the lower half of the stomach to a man asleep in a hammock slung between trees. The hammock represents the transverse colon; the trees, the ascending and the descending colon; the points of suspension, the colic angles. If we will pause a moment beside this man, we will see the following:

If, at the same time, we pull on the two suspension ropes, the position of the man's body is made each time more nearly horizontal. We have an example of the short transverse colon with high, almost horizontal stomach.

If we loosen the hammock rope at the foot, the man's buttocks descend and tend toward the opposite side. We have here an example of ptosis of the hepatic flexure, with the stomach dropped toward the left iliac fossa.

If we loosen or lower the lashing on the head end of the hammock, the buttocks descend and tend toward the opposite side. This demonstrates ptosis of the left colic flexure with ptosis of the stomach toward the right.

If we slacken both lashings, the whole man descends and doubles up. This is total prolapse of the colon, including the stomach and transverse colon, into the pelvis.

If we wish to illustrate the suspending function of the duodenal angle, let us bind the flexed knees of the subject to a branch of the tree on the foot-end of the hammock. If the branch is strong and rigid, its attachment will influence the position of the body in all the maneuvers. We will have all the different types of gastrocolic prolapse with stretching of the duodenal bulb but without duodenal prolapse. If the branch yields and descends beneath the weight of the body, this will be due to variations of the hammock. We will have the different types of gastrocolic ptosis with duodenal prolapse.

Granted, of course, that in these typical cases we refer to a stomach not under the action of its intrinsic muscular fibers and suspensory ligaments. The sleeping man typifies the atonic stomach. But the form and position of even perfectly normal stomachs are always influenced by the colon. The action of the two organs is reciprocal. When the transverse colon is high, it lifts the stomach, allowing it to descend when it is low; but also it may in its descent drag down the stomach by pull upon the gastrocolic ligament or gastrocolic omentum. The stomach by its weight can make the colon descend, but it also can lift it by pulling on the ligament when it rises or is held high by other means, normal or pathologic.

All this we see daily on the fluoroscopic screen. It is exceedingly rare to see a gastric ptosis without colonic ptosis, or *vice versa*. When we see on the screen a gastric ptosis, we may diagnosticate in advance a ptosis of the colon, except in the presence of some gross congenital or acquired anomaly. I, and doubtless all radiologists, have made the same observation, have seen one day a stomach in normal high position with a colon filled with gas; and on seeing it again the following day have found the barium-filled colon lying in the pelvis; we fill the stomach again and see it also ptosed into the pelvis.

The following also frequently occurs: a patient consults a radiologist who says the stomach is normal; not content, the suffering patient goes the next day to see another radiologist who reports marked prolapse of the stomach. The patient concludes that the first radiologist is a fool; the second, content with having won, may or may not defend his colleague.

Radiology is good and useful, but one must know how to apply and interpret its findings. When one studies the stomach, he should also examine the colon, or at least ascertain its state of repletion with gases or heavy material. There are patients who complain of the stomach when they are constipated, but there are others who evacuate the stomach better when the colon is filled.

All this may seem elementary, nevertheless it is conspicuous by its absence in the literature.

* * * * * * * * * *

Let us now consider the anatomical structure of the stomach. I believe that for this one cannot do better than summarize the notable work of Gösta Forssell, of Stockholm, presented at the Roentgen Congress in Berlin, 1912, entitled, "The Relations between the Radiologic Forms of the Human Stomach and the Muscular Structure of the Stomach Wall." He says it is impossible to understand and describe the forms and movements of the stomach such as we see radiologically without admitting their very close relations to the anatomic structure of this organ. According to him, "to give a general description of the stomach whose form varies incessantly while it is functioning, one should not only consider its shadow in different positions of the body and with more or less filling of its cavity, but he should also attempt to ascertain the anatomical architecture which determines those forms and which gives that regularity in its variations." This is the purpose of his comparative anatomic and radiologic investigations. His investigations show that the form of the stomach in life is not only dependent upon a greater or less degree of contraction of its wall, but that each part of the stomach has an anatomically constant, organized structure, that is to say, a typical muscular architecture. This explains the production of the characteristic forms and the typical contractions observed with the X-ray.

In the muscular layers of the stomach there are two supporting systems fixed outside of the stomach and about which the musculature is arranged, as about a skeleton. One of these systems consists of the ligaments of the pylorus, arranged transversely in the lower part of the stomach and fixed outside by the insertion fibers. The second supporting apparatus consists of two vertical muscular structures fixed above to the wall of the esophagus. One of these is formed by a belt of oblique muscular fibers which runs parallel to the lesser curvature as a strong band, inserted along a line like a wide-open "s" between the circular bundles of the body of the stomach, which fibers starting at this line of insertion follow the same direction to the greater curvature. The other vertical structure is the "Swiss cravat." Attached above in the right side of the esophageal wall, it follows the vertical portion of the lesser curvature, and ends at the level of the transverse portion of the stomach canal, where by its arrangement it regulates the level and obliquity of the transverse part of the stomach in relation to the vertical portion.

"In the muscular architecture of the stomach, the dominating principle is the constancy of the typical arrangement of the muscular bundles in relation to the supporting and reinforcing framework."

The arrangement of the muscular bundles in relation to the supporting bands is variable, depending upon whether one studies it at the level of the antrum or at the level of the caudal or cardiac extremity. In the *antrum* the circular muscular fibers are oblique toward the right, almost parallel, and, no matter what the state of contraction, they are always arranged almost symmetrically in relation to the supporting bands. At the *caudal end*, the fibers below the supporting bands spread out fan-wise; the supporting bands here are arranged asymmetrically, the greater part of the circular fibers being found below them; here we have a true sac pre-formed by the muscular arrangement.

"This difference in anatomical structure between the antrum, or pyloric canal, and the caudal extremity, fundus or sinus of

the stomach, explains the well-known form of the normal stomach as seen in roentgenograms made in the erect position."

The two curvatures are not analogous: the lesser is the result of change in the direction of the stomach; the greater, on the contrary, constitutes the fundus of the vertical sac, and the change in the direction of the stomach occurs in the greater curvature, to the right of the cardia, between it and the evacuating canal. The angle of the bend of the lesser curvature has a characteristic muscular structure. The longitudinal layers are here much thinner and the circular fibers are bound together much less securely. This anatomical arrangement is very important from the standpoint of function; it is this part of the gastric wall which, as we see with the X-rays, undergoes the greatest variations and displacements by the continual alterations in position and by the varying degree of filling. When studying the peristalsis of the canal and of the cardia we find that there also the muscular structure is very precisely reflected. The displacements of the walls of the canal occur about a fixed line corresponding to the supporting bands. The peristaltic contractions of the canal are deeper, shorter, and in form more acute than those of the cardia, on account of the parallelism of its fibers.

Now let us consider the relations between the musculature and the systems of vertical support. The branches of the supporting band curve downward toward the great curvature in the form of a very strong fascial bundle, the inferior supporting bundle. This forms a natural division between the cardia and the body of the stomach. The oblique muscular bandlet or sustaining fascia gives to the vertical portion of the stomach its characteristic form. This muscular sling and support plays a rôle of certainly first importance as regulator of the length of the body of the stomach. Only its fixity permits the gastric cavity to preserve its form of an elongated tube. The peristalsis of the body is normally and in certain conditions dependent upon the inferior bandlet, which gives it its typical direction and form. The deep incisure of the greater curvature produced during certain phrases of normal peristalsis in the upper part of the fundus is directed toward the cardia. These deep contractions, occurring without a synchronous corresponding depression in the lesser curvature, are evidently not due to the circular fibers. At the same time, the direction and the form of the depression indicate that the force is directed towards the point of attachment (fulcrum) of the sustaining sling. The contractions of the oblique muscles influence the direction imparted to the food mass. When the subject is recumbent, it is the contraction of the oblique muscles which separates the spherical portion of the stomach from the tubular. At the level of the gastric dome the transverse muscular layer plays a suspensory rôle; its fasciculi attached to the esophagus are directed obliquely downward, while those oblique muscle bundles of the dome which have no external support have a circular distribution. There is an additional reinforcement here from a bundle of muscular fibers starting from the esophagus.

* * * * * * * * * * *

I have transcribed here liberally from the work of Forssell, because, in my opinion, it is the most noteworthy of the published descriptions of the gastric architecture, and because it harmonizes perfectly with the morphological variations which we see daily in radiology, and it throws much light upon the physiologic interpretation of the movements and the mechanism of gastric clearance.

For my part, when I observe a stomach radiologically, I endeavor to adapt to it Forssell's ideas on the structure of the stomach. I believe that the confusion and the innumerable contradictions which we meet at every step in works on gastric radiology, are due to a failure to recognize or remember all these anatomical conceptions, and to false interpretation of the motor physiology of the organ.

As to the physiological aspects, I believe

also that the first thing we should do is to abandon once and for all that old theory which assigns to the hydrochloric acid the rôle of pyloric gatekeeper—a theory set forth by Hirsch in 1893 and strengthened later by dog experiments done under unsatisfactory conditions (duodenal fistulæ of Serdjukov and prepyloric fistulæ of Cannon), and which clinical and physiological teachers have continued to follow in spite of its numerous contradictions with logic and pathology.

The HCl arriving at the pylorus provokes its opening, passes into the duodenum, and, having once arrived there, provokes pyloric closure! The HCl is a well-educated gentleman who opens the door, passes through and then closes the door after himself. This childish idea for more than thirty years dominated physiology and even the field of gastro-duodenal pathology. Physiologists like Richet and Gley follow it, accepting and teaching it. We read in Richet: "So the same chemical agent, the hydrochloric acid, produces successively a phenomenon of inhibition (pyloric relaxation) and a motor phenomenon (pyloric contracture), depending upon whether it acts above or below this orifice."

We read in Gley: "So the same chemical agent, the hydrochloric acid secreted by the gastric glands, produces successively a phenomenon of inhibition, the opening of the pylorus, and a motor phenomenon, the closure of the pylorus, according to whether it acts above or below that orifice." One could not ask closer agreement between the two leaders of contemporaneous physiological instruction. One says "contracture," the other "closure." We need not seek the cause; perhaps both these great masters drank at the same fountain, Cannon. So, our master Navarro would say, are perpetuated errors in our books.

The Italians, Berti and Giavedoni, in their well-known work entitled, "Radiology of the Digestive Apparatus," say: "The fundamental factor in regulating the rhythm of closure and opening is represented by the degree of acidity on either side of the pylorus."

We experience frank relief when we read in Krehl: "We must be careful about applying to man the results obtained in animal experiments. Man is extraordinarily sensitive to stimuli which may seem indifferent. The influence of HCl upon gastric clearance does not seem clear to me."

Recent experiments on man with prepyloric and duodenal sounds prove that the acidity and alkalinity on the one or the other side of the pylorus have no influence on closure or opening.

* * * * * * * * * * *

As I see it, the problem of motility and emptying of the stomach should be outlined thus:

(1) The stomach is a muscular organ. Every muscle acts under the excitation of its nerves.

Every nerve may be excited by various agents.

Conclusion: All agents which stimulate gastric nerves or plexuses have an action on the musculature, and, therefore, on motility and emptying.

(2) The reaction of every neuro-muscular system to exciting agents depends upon these agents and upon the state of the nervous and muscular elements.

The exciting agents which may act upon the gastric nerves are multiple and varied.

The state of excitability of the nervous and muscular elements of the stomach varies in different individuals, and in the same individual from moment to moment.

Second Conclusion: The motility and emptying of the stomach depend upon many agents and upon many circumstances of the moment and of the individual.

Agents and circumstances are well known and too numerous to mention.

We may add, by way of strengthening these conclusions, a good phrase of Krehl's: "The emptying time of the stomach depends, after all, on the combined action of many factors; even in health it varies according to the kind of food, but also in

relation to every possible influence, so in disease it varies within wide limits."

It is absurd to wish to reduce these factors to one single formula and attribute to a single agent, the HCl, the entire control of pyloric opening and closure.

* * * * * * * * * * *

I will not now follow the example of many who overturn one theory just to launch another, but I will dwell briefly upon certain facts which seem clearly evident.

Many agents under various circumstances influence the neuromotor elements of the stomach, but these respond to the stimuli by contractions of muscular fibers. The nerve receives; the muscle responds. The gastric plexuses receive stimuli from higher centers, but they are also autonomous and receive stimuli directly, whether they be mechanical (contact of food, weight of food mass), or chemical (chemical food elements, chemicals secreted by the gastric glands, those carried in by the vessels, etc.), or physical stimuli (temperature, osmotic pressure, electrobiologic action, etc.). To all these different stimuli the motor elements of the plexuses respond in one manner only,—muscular contraction.

The digestive tract sympathetics, as described by Laignel-Lavastine, arranged in distinct plexuses in layers interposed between the various layers of the gastric wall, seem to respond to a sort of excitation from within, aside from the various plexuses and the various muscular and mucous layers.

The first to receive the alimentary stimulus is the mucosa, with its glands; the first response is the formation of gastric juice.

The first muscular layer is the oblique, the suspensory sling of Forssell; the first to contract are the oblique fibers that give the stomach its form, and to the food its direction.

The second muscular layer is the circular, with its deep muscular plexus, well arranged between its fibers; it is this which gives us those circular contractions which progress towards the pylorus, which at first do not do much toward gastric clearance, but which churn the mixture of foods and gastric juice.

The last layer is the longitudinal, the last to be found in normal stomachs; this provides those broad, shallow waves which run slowly along the greater curvature, and which, in combination with circular contractions near the pylorus, open it and allow food boluses to pass into the duodenum.

The longitudinal fibers are in intimate contact with the plexus of Auerbach, interposed between them and the circular fibers. Auerbach's plexus innervates also the circular coat, but this has also its own plexus. Auerbach's plexus is also in communication with all the deeper plexuses. It is the most important plexus of the digestive tract, extending from the esophagus to the rectum, richest in ganglion cells and nerve fibers. The longitudinal muscular coat depends on it exclusively; the other coats have their own plexuses in addition. Auerbach's plexus is the commanding general, who receives communications from all his chiefs of division, and orders the general conduct of the battle, but who has at hand a powerful reserve to launch at the opportune moment. This reserve consists of the *longitudinal fibers; they act at the proper time to open the pylorus* to permit the escape of a bolus of food brought to this point by the circular fibers.

The stomach treats the food as an invading enemy; it maltreats it, beats it, transforms it, renders it harmless before casting it into the territory of its good neighbor, the intestine. If the enemy is bad and overpowering, Auerbach's plexus, the commanding general, asks for reinforcements from his superiors, the central neurons, the vomiting center, who, sending to the attack outside forces, forces everything to leave by the way it came, and peace is restored.

So I conceive gastric physiology. I think we should attribute to the nearly forgotten longitudinal fibers, the rôle corresponding to the evacuating mechanism of the stomach. Innumerable radioscopic observations covering many hours of screen

work have brought me to this firm conviction.

Frequently we observe the following: We fill a stomach; while it is filling, some of the food passes rapidly into the duodenum, after which the organ remains quiet with a moderate depression in the left side. Some minutes later a deep circular contraction segments the horizontal portion of the stomach and advances toward the pylorus, giving one the impression that it is going to pass a bolus through the pylorus; nevertheless not a single drop passes into the duodenum; two, three or more contractions follow with equally negative result. "Pyloric obstruction," some bystander remarks. "Wait and see." At a given moment a gentle, broad, shallow wave appears on the greater curvature near the junction of the body with the fundus, precisely at the point designated by Forssell as the site of the inferior supporting band; this wave progresses slowly pylorusward, in the neighborhood of which it synchronizes or fuses with a circular contraction, and then, without great ado and when we least expect it, we see the duodenal bulb well filled.

Again we see a typical ptosed atonic stomach; a nicely rounded convexity, without a wave, marks the lower border of the stomach situated well below the umbilicus; no pyloric canal is seen. Some minutes pass, but no movement is noted. We wait. A gentle wave, fairly deep, begins on the left side of the shadow and slowly advances towards the pylorus; other waves follow and finally three or four waves may be seen at one time on the greater curvature, and the stomach empties without any change in the appearance of the lesser curvature. These waves can be due to nothing else than the contractions of the longitudinal fibers. At certain times these contractions offer points of support to the circular fibers when these exist; it is these contractions which shorten the greater curvature and lift the fundus of the stomach. These longitudinal fibers, by their perfect continuity with the corresponding fibers of the duodenum, when they contract near the pylorus, using the duodenal angle as fulcrum, pulling from the gastric side, shorten and efface the gastro-duodenal sulcus and dilate the pyloric orifice. The wave opens the pylorus before it reaches it; when it does reach there, it falls into the sulcus, slackens the pull, and the orifice closes itself by its own elasticity or by the arrival of the circular contraction. The wave continues in the duodenal bulb, combines its action with that of the circular contraction, and, with the closed pylorus as fulcrum, pulls upon and opens up a little the duodenal angle, permitting the bulb to empty, and continuing without delay through the whole length of the small intestine. In the latter, the two contractions, circular and longitudinal, are synchronous; they proceed in harmony, the longitudinal pulling, opening the way, overcoming obstacles, ironing out folds in the intestinal wall; the circular, by pushing along the material, causing it to advance. Thus I interpret the law of the intestine, of Bayliss and Starling.

For some reason, Nature gave the entire digestive tube two distinct muscular coats. Whether these fibers are arranged according to the old idea of an inner circular and an outer longitudinal layer, or whether, according to the modern conception of Eben J. Carey, in two spiral coats, an internal coat with very fine spirals, the other, external, with large spirals measuring twenty to fifty cm. to a turn, the mechanism of progression of bowel contents is the same, and is always due to a synchronizing of the contractions of the two coats.

The contractions provoked in these coats of muscular fibers by the many varied agents stimulating the digestive sympathetic system, are independent in the stomach and synchronize at the moment of emptying; they always travel together and are always synchronous in the small intestine; they are once more independent in the large intestine and only at certain moments do they combine and synchronize to produce great progressions of bowel content or its evacuation.

This is my conception of the neuro-motor physiology of the gastro-intestinal tract.

A PRACTICAL METHOD FOR THE ROUTINE DETERMINATION OF THE QUANTITY AND QUALITY OF X-RAYS [1]

By EDWIN C. ERNST, M.D., F.A.C.R., F.A.C.P.

From the Department of Radiology and Research of the Barnard Free Skin and Cancer Hospital, St. Louis

THE intensity or effective wave length output of our present high tension X-ray transformers and X-ray tubes does not appear to be either scientifically or practically uniform and constant; at least, not sufficiently accurate to permit the desired exact duplication of dosages, even though the determinations are made under the most favorable conditions of constant voltage and tube current. A review of the many careful recent researches of the physicists studying these problems more or less substantiates our practical experiences and observations in the administration of X-ray dosages in our daily clinical routine treatments, and the results observed in our biological researches at the Barnard Free Skin and Cancer Hospital.

Duane has recently stated that "Variations of 40 per cent and more in the intensity of the X-ray projected through the same filter and at the same distance from the tube with different machines are not uncommon, and in the extreme cases one machine may project twice as much X-radiation as another."

Many physicists and investigators, including Glasser, Mutscheller, Erskine, Kelly, and Fricke, have predicted that spark gap estimation and energy input valuation will become obsolete, since the presence of so many variables almost necessitates measuring the *output* of the tube rather than the *intake*.

In the past the usual standard sphere gap measurements and milliamperemeter readings have been erroneously considered the basis or indications of the quality and quantity of the filtered X-rays employed in the treatment of benign and malignant disease. It seems to us, however, that uniform results can neither be expected nor duplicated under the above conditions. It is becoming more and more self-evident that perhaps the great irregularity in results reported at meetings in the past are traceable to our present inaccurate method of defining and measuring the X-ray dose.

Failla recently stated that the present radiation technic is due almost entirely to chance. We use whatever amount of radiation is available, or the voltage and current our machine can deliver, and then we adjust the treatment accordingly. If we have obtained some good results it is perhaps by mere accidental coincidence. That is indeed a most serious indictment.

If the above deductions are partly correct, then even the study of the unknown biological phenomena must be considered secondary to the physical standardization of our X-ray beam. The biological phenomena of radiated cellular tissues as a whole cannot be interpreted and duplicated with precision, and, therefore, such changes are not of practical value unless considered in terms of a known physical agent producing such an effect. It would seem most logical and opportune to, first of all, continue our efforts in the latter direction, provided we do not ultimately find the many variable factors and physical obstacles too difficult of elimination in the production of our X-rays. Perhaps our present efforts are misdirected and an entirely new method of attack or a new type of measuring instrument will be the only final solution. Improvements in the electrical transformation of our low voltage currents into X-ray energy would greatly simplify our problem. For many years past we have been emphasizing the necessity of added precision in the routine X-ray radiation therapy, expressing the desirability

[1] Read before the Radiological Society of North America, at Atlantic City, May, 1925.

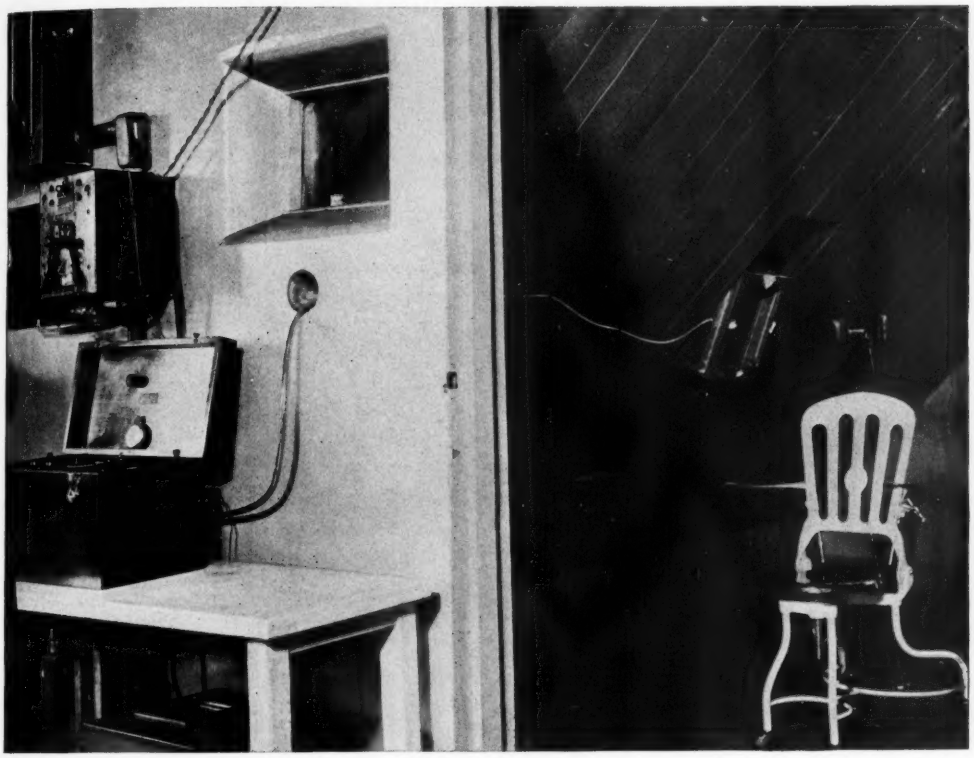

Fig. 1. Composite view of the ionization chamber, with cable in position, for measuring the output of the X-ray energy of the tube during the administration of the treatment.

and hope of eventually being able to more uniformly standardize the output of our X-ray machines. It may be superfluous to again bring this matter to your attention since the majority of the radiologists and physicists here no doubt fully realize our present limitations in attempting to both practically and accurately measure the quantity and quality of our X-ray machines by means of the input valuations alone, namely, voltage and sphere gap deductions.

However, I am extremely anxious to again stimulate your interest in this matter in the hope that I may invite your frank discussion of these measuring problems from the viewpoint of both the physicist and the radiologist. At the same time, I likewise desire to take this opportunity of presenting for your consideration and criticism a description of the methods which we have adopted towards keeping the output of our X-ray machines uniform, after first having them standardized in the manner to be described. However, primarily, I sincerely hope to create additional interest and perhaps stimulate the necessary concerted action among the members of the Radiological Society of North America towards the possible creation of a standardization or investigation committee for the study of our many X-ray dosage problems. Such a committee or commission of practical radiologists and physicists might help in a co-operative way to analyze these problems on a basis of the experiences and viewpoints of individual members. They would then be in a position, after individually and collectively studying and investigating these measurement problems, to present their combined conclusions and rec-

ommendations. It might even be possible that a preliminary report could be presented at the next annual scientific session of our Society, so that these initial recommendations could be further discussed by the members at large. Such information would not only prove to be profitable and have scientific merit but would also present essential data to radiologists interested in radiation therapy.

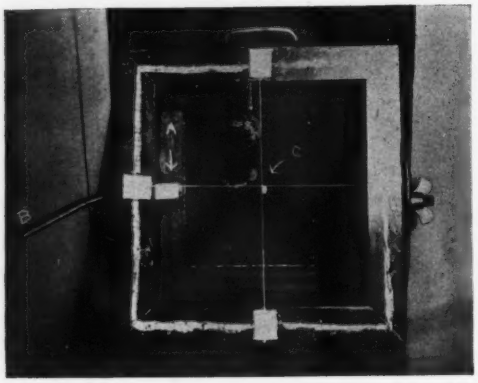

Fig. 2. (*a*) Fixed ionization chamber; (*b*) iontoquantimeter cable; (*c*) X-ray tube target.

We fully realize the extremely complicated, yet closely interrelated, biological and chemical aspects of this problem to the purely physical considerations. It is not my purpose to discuss the biological problems at this time, nor do I wish to discuss in detail all of the physical problems, but it has been our experience that

(*a*) the quantity of X-ray radiation per cubic centimeter;

(*b*) the quality of radiation employed;

(*c*) tissue distribution of X-ray beam;

(*d*) the surface and depth intensity;

(*e*) the exposure time, and

(*f*) the time intervals between either the complete single or between the divided multiple doses have a direct and important bearing upon the pathological tissue changes; both the local effect at the site of the lesion, as well as the systemic reaction produced throughout the normal structures of the body as a whole.

Wood and other investigators have reported many interesting observations relative to the type and quality of X-ray radiations and the supposed biological effects and tissue changes thus produced. Nevertheless, the logical importance of the physical aspects of radiation therapy as to the employed quality and quantity of X-ray cannot be denied, and a new and more exact method must be devised to supplement the ordinary observations of voltage and tube current measurements. This could be accomplished by an instrument of precision, measuring the quality and quantity of the output of our X-ray machines in a simple and practical manner, even though supplemented by all of our present methods of measurement. Many scientific instruments have been devised by Duane, Friedrich, Besser, Mutscheller, Kegerreis, Beets and others, including the many novel spectroscopic types of apparatuses, but from a practical standpoint they have all been found wanting to a greater or lesser degree. Since the depth dose percentage or the effective wave length in Angström units conveys the concept of quality it should always be included in our calculations when reporting the quantity units (milliampere minutes) of X-ray employed. The usual dosage factors of peak voltage, milliampere minute readings, filtration, focal skin distance, size of field, are important calculations in determining the dosage. Nevertheless, the presence of the many variables does not convey to others the effective 10 cm. depth dose quotation, nor does it define the average or effective wave length. Nor could such a dosage be duplicated with any degree of accuracy by other therapeutists.

As soon as we observed that the current was running smoothly through the water-cooled tube, both surface and depth dose measurements were made with a small horn ionization chamber (1.5 cm. $\times$ 1.5 cm.). The discharge time of the "standard" iontoquantimeter employed was four minutes with 50 mgms. radium element. The unnatural leaks, although almost negligible, were accurately deducted. In fact, the

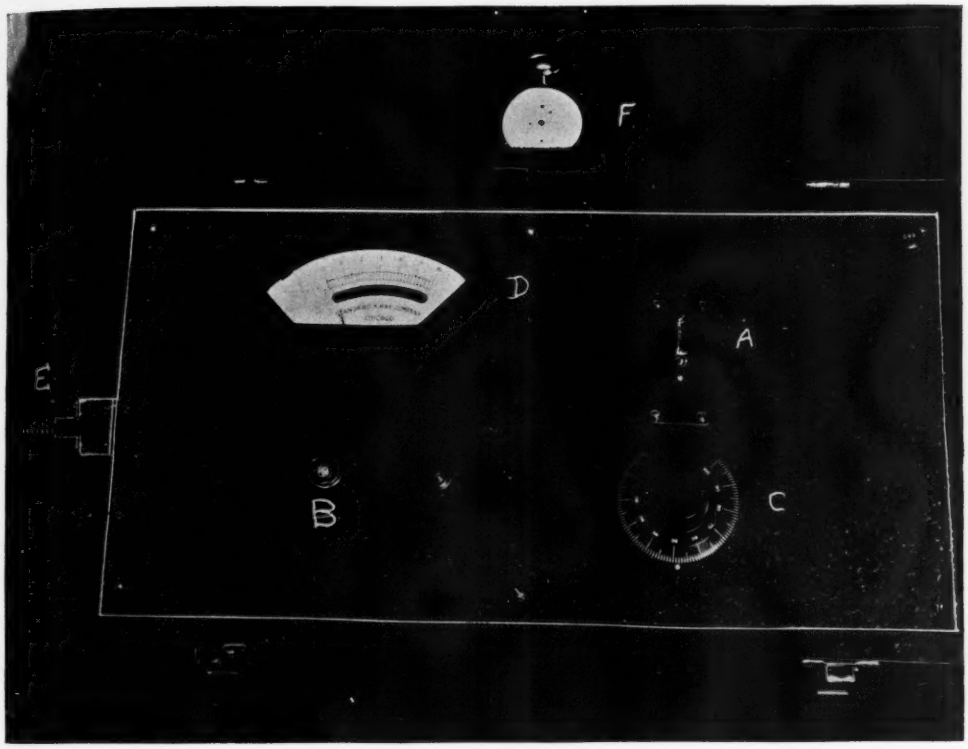

Fig. 3. (*a*) Transformer switch; (*b*) automatic needle switch; (*c*) rheostat; (*d*) iontoquantimeter scale; (*e*) cable to ionization chamber; (*f*) stop watch.

behavior of the iontoquantimeter under all conditions for a period of many months was most reliable and efficient. After carefully considering the many phases of radiation therapy we decided to attempt to obtain a uniform ten centimeter depth dose (water phantom) of 50 per cent when employing a filtration of 1 mm. cu. plus 1 mm. of aluminum at a focal skin distance of 80 cm. To accomplish this depth dose the sphere gap voltage readings remained approximately at 215,000 volts, when 25 milliamperes passed through the tube. During the period of charting our various depth curves with different filters repeated measurements were taken with the ionization chamber in the fixed position, as shown in Figures 1 and 2. These readings were also charted, as shown in Figure 7. Therefore, by definitely establishing our standard depth dose of 50 per cent by actual water phantom measurements, and then at the same time, under the same conditions, likewise observing the discharge time of our iontoquantimeter with and without the auxiliary filter of 5.5 cm. wax in position (Fig. 2), we were able to check the one method against the other. The latter method of employing an auxiliary filter of wax and comparing this reading with the one obtained when the wax was withdrawn, proved most practical and absolutely dependable. The slightest variation in our depth dose quality of 50 per cent was immediately discovered by the latter indirect readings in seconds. Our input voltage readings frequently vary as much as five volts, and these variations definitely increased or decreased the depth dose quotation. In Figure 7 the small numbers in the upper right-hand corner of the individual squares represent the

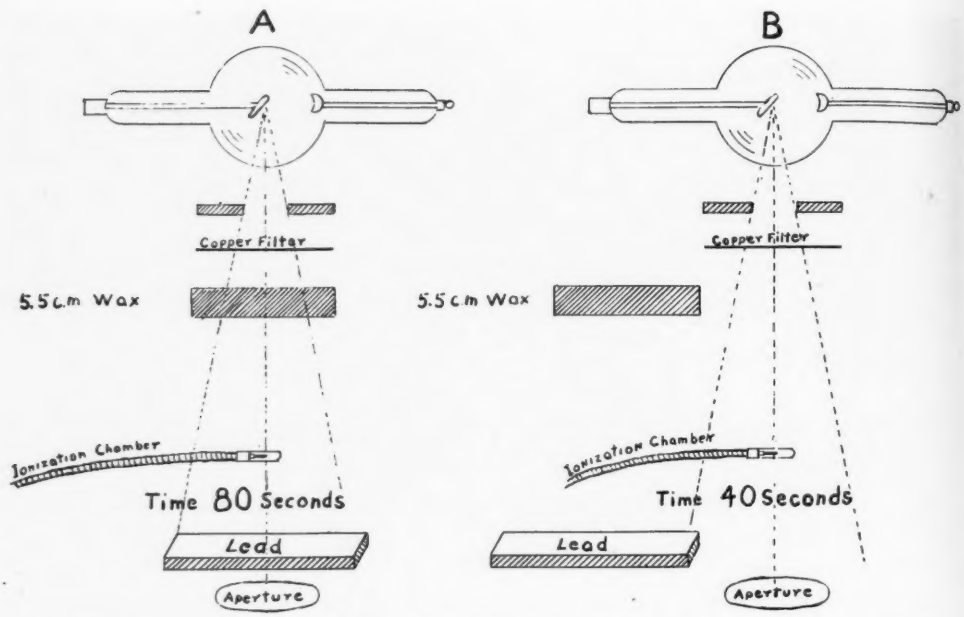

Fig. 4. Schematic drawing (*a*) presenting the auxiliary filter (5.5 cm. wax) in line with the X-ray beam. The position of both the normal copper filter and the ionization chamber is likewise shown. In (*b*) the wax filter is withdrawn.

readings during a drop of five volts in our primary current. Instead of a surface intensity of 71 seconds, the reading was 81 seconds, and when the auxiliary filter was employed a variation of from 139 seconds to 159 seconds was readily noted. In Figure 1 a composite view is had of the ionization chamber in position, together with the extension cable of the iontoquantimeter box to the instrument board of the high tension apparatus in close proximity to the operator. This permits the regular checking of the output of the machine before, during, and at the end of each treatment, and without loss of time. A close-up view of the iontoquantimeter is shown in Figure 3.

The following procedure has been adopted in all of our experimental and routine clinical treatments:

(*a*) The patient is placed in position for treatment. The ionization chamber remains in a fixed position within the path of the X-ray beam.

(*b*) A lead slide protects the patient from obtaining any X-ray radiation during the initial measurement.

(*c*) As soon as 25 milliamperes are observed passing through the tube with a primary voltage of 174, as shown upon a specially constructed and very delicate laboratory voltmeter, the auxiliary filter is placed in position by means of a pulley arrangement, and the reading taken in seconds. When employing 0.5 mm. cu. as a regular filter, 80 seconds is the normal discharge time.

(*d*) Immediately thereafter, without turning off the current, the lead slide is automatically removed, as well as the auxiliary filter of 5.5 cm. of wax, and the discharge time should now read 40 seconds. The treatment is now in full progress. This latter check may be repeated at intervals during the treatment without disturbing the primary X-ray beam or the patient. At the end of the treatment the lead slide is again inserted, and the auxiliary filter of wax interposed, and a final reading is

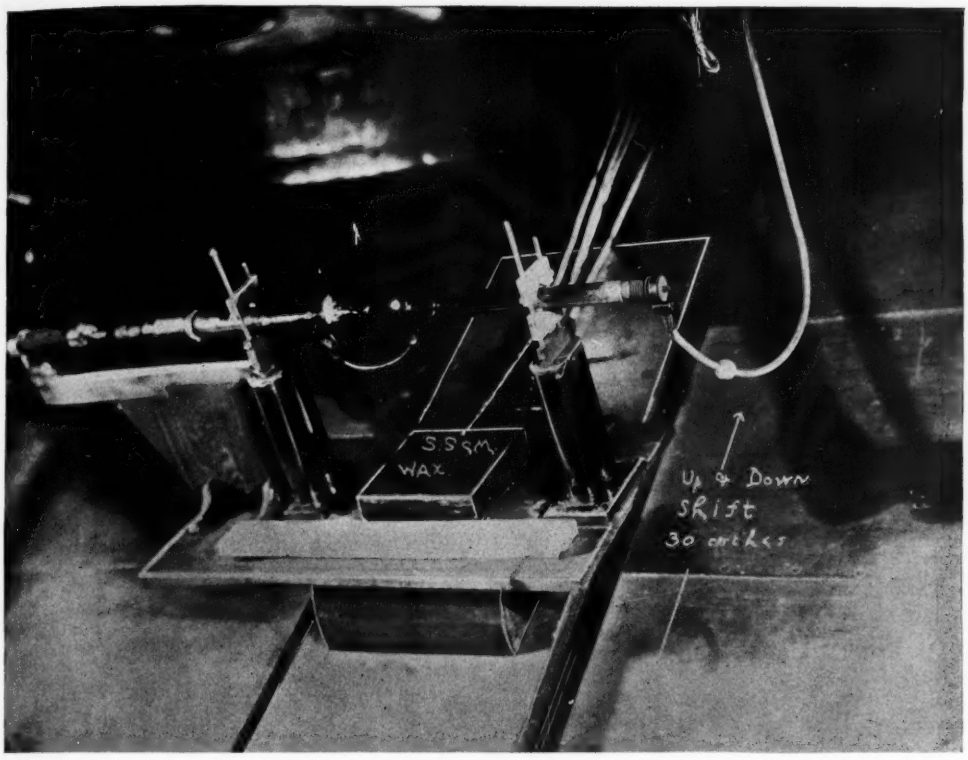

Fig. 5. Tube in position for treatment, including the usual copper filtration and also the auxiliary removable filter of 5.5 cm. of wax. We have also employed an auxiliary filter of 0.65 mm. copper in place of the wax.

taken which should again show a discharge time of 80 seconds. This procedure absolutely insures a uniform and constant tube output.

Errors in filtration are likewise checked by this method; in fact, as shown in Figure 7, the exact filter present in the tube holder can be readily determined by the operator at the initial reading, during which time the patient receives none of the X-ray radiation, since the lead slide covers the diaphragm. This primary period of measurement likewise allows the tube to become sufficiently warm so that the output is uniform. Occasionally water-cooled tubes show considerable "gas" and this variation can likewise be compensated for by means of the methods here described.

(*e*) The method of charging the iontoquantimeter is extremely simple. By depressing transformer switch *a*, in Figure 3, and pressing button *b*, the ionization chamber is fully charged *instantly* to any desired point upon the scale as regulated by the rheostat *c*. The discharging rate of the needle over the scale can then be checked in seconds over a fixed division of the scale *d*. This process of charging and discharging the ionization chamber can be continued throughout the administration of the treatment. In our routine treatments we largely employ 0.5 mm. cu. as a filter. In our superficial breast malignancies either 0.25 mm. cu. or 4 mm. of aluminum is routinely employed. The former readings should register 80 and 40 seconds, respectively, with and without auxiliary filtration of wax, and when a quarter of a millimeter of copper is employed the respective readings are 53 and 25 seconds. The superfi-

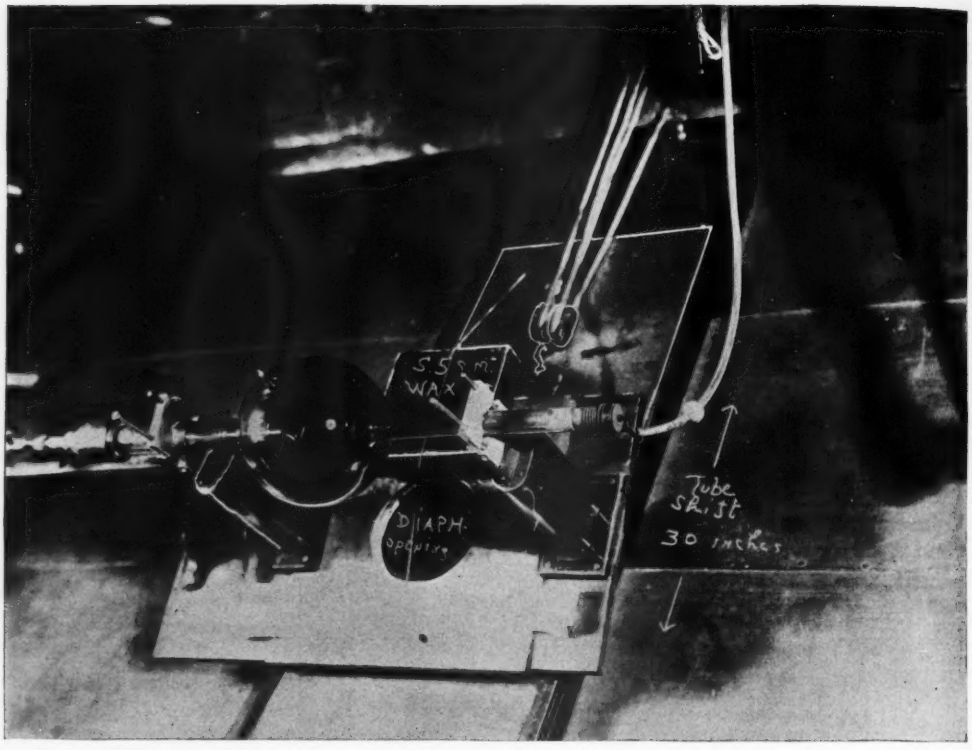

Fig. 6. Tube in position for treatment, same as shown in Figure 5, with the exception of the auxiliary filter of 5.5 cm. of wax or 0.65 mm. of copper.

cial radiations with 4 mm. of aluminum under all of the above conditions show a discharge time of, respectively, 37 and 16.5 seconds. In Figure 4 the method of employing an auxiliary filter of wax or the equivalent of copper is graphically shown.

SUMMARY

Every installation employing high voltage currents should be carefully checked as to the output of the radiation energy employed, preferably by a trained physicist. At the same time, however, a method must be devised to regularly check this output of X-ray energy both as to the quality and quantity, otherwise, mechanical or electrical variations of the installation may not produce the desired uniform quality output of radiation energy.

Therefore, the simple apparatus and scientific instruments and the method of obtaining the effective wave length of X-ray energy, as described above, have proven not only valuable but most essential in helping us to maintain a uniform quality and quantity of radiation, not only from day to day, but also during the administration of our treatments.

We believe, therefore, that the time is most opportune for the formation of a standardization or investigation committee for the study of our many X-ray measurement problems along the lines previously described, and that perhaps such a commission might help stimulate efforts in the direction of a national or international *standard unit* of X-ray energy.

BIBLIOGRAPHY

1. DUANE: Measurement of Dosage by Means of Ionization Chambers. Am. Jour. Roentgenol. and Rad. Ther., May, 1923, p. 399.

Time in Seconds of Discharge of Iontoquantimeter with and without Auxiliary Wax Filtration
Average Voltage Measurement 215 KV (Sphere gap 5 c.m.)

Therapeutic Filtration	4 m.m Al	.25 m.m. Cu	.50 m.m. Cu	.75 mm Cu	1.0 m.m. Cu
Without Auxiliary Filtration	16½ [193] Seconds	25 [29] Seconds	40 [46] Seconds	56 [65] Seconds	71 [81] Seconds
With Auxiliary Filter of 5.5 m.m Wax	37 [43] Seconds	53 [60] Seconds	80 [93] Seconds	110 [129] Seconds	139 [159] Seconds

Measurements made with standard iontoquantimeter. Size of horn ionization chamber 1½ x 1½ centimeters. Standardized by 50 milligrams radium element. Time, four minutes, at 1 mm. distance.

Fig. 7. The large figures within the squares represent the discharge time in seconds at 215 K.V., with and without the auxiliary filter. The small figures represent the discharge time in seconds when the primary voltage fluctuated five volts.

2. Beets and Arens: Practical Aspects of X-ray Measurement. with Special Reference to a Standard Unit of Dosage. Radiology, March, 1924, p. 172.
3. Beets and Arens: Physical Measurements and Comparative Technic in Relation to Biological Dosage. Preliminary Report. Radiology, Oct., 1924, p. 293.
4. Mutschelle: Average Wave Lengths of X-rays. Radiology, Oct., 1924, p. 328.
5. Holzknecht: The Safety Value of the Direct Measurement of the Surface Dose in X-ray Therapy. Radiology, Feb., 1924, p. 56.
6. Friedrich: The Problem of Ray Dosage. Am. Jour. Roentgenol. and Rad. Ther., Jan., 1923, p. 6.
7. Fricke and Glasser: Studies on the Physical Foundations of Roentgen-ray Therapy. Am. Jour. Roentgenol. and Rad. Ther., May, 1924, p. 435.
8. Nims: Deep Therapy Simplified. Radiology, Nov., 1924, p. 394.
9. Mutschelle: Ionometer for Relative Measurement of Primary X-rays. Radiology, May, 1924, p. 330.
10. Duane: Ionization Methods of Measuring X-ray Dosage. Am. Jour. Roentgenol. and Rad. Ther., Dec., 1923, p. 935.
11. Failla: A Brief Analysis of Some Important Factors in the Biological Action of Radiation. Am. Jour. Roentgenol. and Rad. Ther., Nov., 1924, p. 454.
12. Weatherwax and Leddy: Further Studies of Ionization Measurements of Roentgen-ray Intensity. Am. Jour. Roentgenol. and Rad. Ther., Aug., 1924, p. 110.

DISCUSSION

Dr. Otto Glasser (New York): The presentation of Dr. Ernst's paper is extremely valuable. Out of my own experience, I can support the statements Dr. Ernst made on the variation of the output of different transformers and even of the same transformer under different conditions. If, for instance, the attempt is made to reproduce certain doses on different transformers just by reproducing the same sphere gap and milliampere reading, the difference in the actual output may amount to 100 per cent or even more. Such large variations can, of course, be avoided if the machines are standardized before being used. Even then, however, there are variations in the dose up to about 20 per cent, due to fluctuations in the line, to unfavorable weather conditions, etc. The best way to arrive at the control of the dose applied is to check the output constantly by means of a dosimeter, as demonstrated by Dr. Ernst. In such a case it is possible to control the output with an accuracy of a low percentage. The experience teaches us that in order to avoid serious mistakes the machine ought at least to be standardized; the more exact way is to check the output constantly by means of a dosimeter.

There is some difficulty as to what kind of dosimeter is to be recommended for practical use. We heard from Dr. Orndoff and Dr. Schreiner that, up to now, in spite of valuable results, we have not known the essential biological effect of radiation. If we knew the mechanism of the action of the rays on the cell we could perhaps devise a dosage instrument which could reproduce to a large extent the action in the cell. So far, however, we are not able to even measure the radiation energy absorbed in the tissue with any degree of accuracy. Looking for a practical dosimeter, we have to study, therefore, all the specific actions produced by radiation,—actions of a physical, chemical or physiological character. We have to correlate them with the biological effect to be measured. One such action of the rays which has proven valuable is the ionization in air. The ionization in air runs parallel to the biological effect on the skin over practically the whole range of wave lengths used in therapy. Therefore the ionization in air has become recognized as the best process to measure dosages.

We may mention here that not all ionization instruments use the determination of the pure air ionization, but that this air ionization is effaced by wall radiations from aluminum, graphite, horn or even higher atomic metals. Generally, it can be stated that the instrument is the more valuable the closer the ionization produced is to the air ionization. An electrical unit, the *e*-unit, has been adopted and used for many years as an ionization unit to indicate radiation dosages. This unit was given the name "Roentgen," or "R," by the German Roentgen Ray Society about a year ago. All instruments ought to be standardized in this *e*-unit, or *R*-unit, so that all laboratories might speak the same language. Dr. Fricke and myself made a number of determinations of the erythema dose in *R*-units, and found about 1,400 R to produce an erythema of the first degree, using fairly hard rays.

The experimental definition and measurement of the unit has to be done in biophysical laboratories; instruments for the practice have to be standardized there and sent to the doctor. For the standardization, the radiation quality has also to be indicated either in effective wave length or in half value layer, or, for given technical conditions, as deep dose.

The arrangement Dr. Ernst showed to control quantity and quality could be improved by standardizing it in *R*-units; it then would be an ideal complete dosimeter.

The formation of a committee on standardization, as suggested by Dr. Ernst, is not only desirable but seems to be absolutely necessary. The confusion in the questions of practical and absolute dosage existing to-day can be cleared up only by systematic co-operation of all the branches in the new science of radiology. I am sure that many of the unsatisfactory results in radiation therapy are not to be blamed to the X-rays in general, but to their unsatisfactory and unscientific application.

Dr. L. E. Pariseau (Montreal): Years ago, in Chicago, I read a paper with a very pessimistic title: "Unsolved Problems and Debatable Points in Short Wave Therapy." Time has flown and the problems are still unsolved. However, we need not be discouraged, for we certainly have forged ahead. It is easy to ascertain how far and how fast, because the progress of our measurements gives the measure of our progress. We no longer trust "arithmetical computation" of dosage and have, quite rightly, turned to ionometry. Unfortunately, the various ionometers, intensimeters and iontoquantimeters cannot be compared; Babel has resulted.

But some day we will be able to determine with accuracy and without trouble the quantity of energy radiated from our tube and that spent in our patient. Even then we still will be nowhere, unless we have solved our biological problems. Eventually we radiologists, not the physicists, will have to tackle such problems. It is hard to say along what lines our investigations should be pursued, but let us turn away from erythema and give heed to changes wrought in the "humors" of the body.

Radiation sickness, surgical shock, and anaphylaxis are, after all, related. Why not place our hope in such studies as those of Lumière on the flocculation of colloids? In other domains, quite as obscure as ours, technics are being evolved that actually compel living tissues to speak up. As an illustration, let me quote the recent work of Leconte du Nouy at the Rockefeller Institute. You know how diphtheria antitoxin is prepared. Horses have no means of letting us know when they are immunized. Chemical analysis is useless and biological controls are tedious. Instead, Mr. du Nouy takes the surface tension of the animal's blood as the inoculations proceed, and plots his observations. A very characteristic kink in the curve shows that the hypothetical antibodies are in fighting trim. We, also, should derive great help from anything that would allow us to estimate the systemic reactions of our patients to radiation. We *must* some day have a

biological unit, even though it be partly nullified by the vagaries of life.

In the meantime, we should gain the mastery of our tools, and schemes like that of Dr. Ernst are very precious, indeed. Unfortunately, we cannot as yet exchange notes, for lack of a physical unit, a truly practical one, defined in terms of the C.G.S. System. Neither Friedrich, Duane, Dauvillier or Solomon can hope for international recognition of his child. The method of Solomon is the least exact but constitutes a very simple and sufficiently accurate control of the tube, the ionometer and the generator. As demonstrated to me in Paris, last summer, the ionization chamber is shoved through a hole in the cover of a cylindrical lead box having an internal diameter of four centimeters and walls one centimeter thick. A radium needle containing at least ten milligrams of the element filtered through 0.5 of platinum is suitably supported at two centimeters from the axis of the ionization chamber. The time of fall of the gold leaf is observed and the intensity of the radiation expressed in so-called *R*-units. Whatever the scientific value of his unit, Solomon's procedure would appear to me as a very happy complement to Dr. Ernst's, and both combined constitute a splendid check-up.

But again I remind you: when we will have standardized our tools we will, nevertheless, be *nowhere*. The physiological and pathological responses of the organism to our treatments are still unmeasurable because they are still unknown.

Dr. B. F. Schreiner (Buffalo): I would like to emphasize what has been said, that it is time we all began to speak in the same language as to the dosage administered. All these problems, presented by Dr. Glasser and Dr. Ernst, have been more or less part of the development in our institution. We have gone through the same steps and have found here and there something wanting. We have to-day, I believe, satisfactory standardization of our equipment there and I might say that we have gone farther; we have gone along the line of the last speaker, and Dr. Stenstrom is now carrying on work on the ultra-spectroscope, trying to define, if possible, any action on the blood serum produced by radiation therapy. So far it has been discouraging. He has learned some things, and probably in the near future will learn a great deal more, as applied to X-ray therapy.

Dr. Albert Soiland (Los Angeles): If this discussion on standardized technic leads to a single important conclusion, it is that we must learn the dosage—that is what we have been trying to do for years—to learn the actual dosage. That can be accomplished only in the way Dr. Ernst has been doing it, with the assistance of the physicists. The remarks of Dr. Glasser and Dr. Pariseau are both leading in the proper direction. There is one thing we cannot entirely dismiss,—that is the suggestion brought out this morning that we cannot place any reliance on the electrical measurements. I do not think that is entirely correct. A great many years ago, before we had any knowledge of measurements of any sort, we still attained therapeutic results with the use of X-rays, perhaps empirically, to most of us, but some of the results stand to-day without challenge. For that reason I believe that the man with an abundant clinical experience who works carefully and who has not the facilities of the standard instruments of precision, still may place some reliance upon a carefully worked out electrical measurement basis. I feel that is correct, but that the most important item is common sense based upon personal clinical experience.

Dr. Edwin C. Ernst (closing): Replying to Dr. Soiland's remarks, I wish to state that it is true that some of our results were, indeed, remarkable, but it must be taken into consideration that the cases quoted were perhaps unusually susceptible to radiation therapy and, consequently, the reactions were most favorable. And fur-

thermore, I likewise desire to emphasize the fact that even though cases appear favorable to radiation treatment, nevertheless, a possible variation of 40 per cent, 100 per cent, or 300 per cent is a serious matter to the radiotherapist, especially when the rays are to be absorbed by the deeper structures beneath the skin surface. A surface intensity variation of but 10 per cent when directed through multiple ports of entry may greatly change the total depth dose quotient, sufficient to produce undesirable and inaccurate radiation effects within the tumor and the surrounding normal structures. Therefore, it is essential that the output of our machines should receive the most serious consideration, if we ever hope to accurately duplicate or compare radiation effects.

Referring to the remarks made by Dr. Pariseau, I wish to state that I partly agree with him that, after all, the ideal unit of X-ray dosage is the biological one. It is nevertheless true, from a practical standpoint, that we cannot hope to make further favorable progress in our final results with radiation therapy unless, first of all, we improve our methods of administering given amounts of physical radiation energy. I fully realize that some of my friends may feel that I have been far too critical about radiation measurements and standard radiation units, but my experiences with many types of installations have made me realize that if we will but review our work and carefully check the output of our machines, not infrequently we will find the things which we thought we were doing are but mere suppositions. A known standard biological dose or a known biological effect is most desirable and essential; nevertheless, such a given amount of radiation energy must, after all, be known in terms of a physical unit or units of measurement. If we can standardize the output of our machines in terms of a standard physical unit, then the problem of comparing such a quantity of radiation energy to known biological effects will be very much simplified.

In our work, employing, as we do, a voltage of 215,000, thirty milliampere water-cooled tube, 80 cm. focal skin distance, and extremely light filters—ranging from 4 mm. of aluminum to ¼ mm. of copper for our superficial breast therapy—it is most essential to accurately measure and repeatedly check the output of our machines.

Many devices have been described and adopted to facilitate the making of such measurements, but ionization under definite prescribed physical conditions remains unquestionably the most practical method in use to-day. This point was especially emphasized by Dr. Glasser. We all realize that these ionization methods will require further physical investigation, although in our laboratories we were fortunate in being able to eliminate many of the objectionable features of the early iontoquantimeters. Leakage of stray currents and other possible sources of error were practically eliminated. This was partly due to the type of instrument employed, but largely because of the fixed position of our instruments. The ionization chamber is always in position near the operator, and radiation readings are made at repeated intervals throughout each individual treatment. These instruments are not moved from place to place for the purpose of making other measurements.

It is our aim to obtain a uniform 50 per cent ten centimeter depth dose type or bundle of X-rays when employing 1 mm. of copper as a filter, irrespective of the voltage or the focal skin distance. In addition, these radiations are measured in *e*-units and comparisons are made with other supposed units of measurement. This latter method alone does not indicate the quality of the X-ray radiation in the deeper structures of the body, and for that reason we employ a combination of the two methods.

This entire problem must be simplified

and this can best be accomplished by a national or perhaps an international committee. Therefore, we made the suggestion that a committee of three practical radiologists, three physicists, including also a biologist and chemist, might help solve these problems. After an interval of three to six months a preliminary report could be presented to this Society, but the work must be continued over a period of at least several years, investigating the many methods of value, offering recommendations or conclusions relative to a standard unit of radiation energy, and perhaps evolving an instrument which would help to standardize such a unit in our individual laboratories.

No doubt, many radiologists will continue to do practical X-ray therapy without measurements, but the science of radiation therapy cannot hope to progress favorably in the future unless this weapon at our command is better understood, and our collective results are compared under more favorable conditions.

STASIS IN THE ASCENDING COLON SIMULATING CHRONIC APPENDICITIS [1]

By T. D. CUNNINGHAM, M.D., DENVER, COLORADO

SINCE Fitz's paper on acute appendicitis directed attention to the right lower quadrant, the literature on the appendix, cecum, and colon has reached tremendous proportions. Most of this literature has been on the surgical relief of pathological processes and has marked a great step in the cure of many of these conditions. Nevertheless, there are conditions in the cecum and ascending colon which are not primarily surgical and are not relieved by surgical intervention. Reference is made to an increasing group of patients who suffer from disturbed digestion, commonly considered as due to chronic appendicitis, but who are unrelieved though their appendix has been removed. Some state they are worse than before the operation. It is to this group, who have no demonstrable surgical pathology by X-ray or physical examination, and who have not been relieved by operation, that your attention is directed.

In reviewing the literature of this phase of digestive troubles, there are several papers,[2] published within the last three years, which give evidence of unrest in the clinician's mind as to the cure of all cases by operation who have symptoms usually referred to as chronic appendicitis.

The most startling evidence which suggests that perhaps the problem is essentially medical is the observation on native tribes in India by McCarrison,[3] who says: "During the period (nine years) of my association with these people I never saw a case of asthenic dyspepsia, of gastric or duodenal ulcer, of appendicitis, of mucous colitis, or of cancer, although my operating list averaged four hundred major operations a year." He attributes the lack of the above gastro-intestinal diseases to the fact that these people eat plain, wholesome, natural foods and take plenty of exercise. Also, he fed twenty-four monkeys on sterilized and more or less civilized rations, with the result that they developed colitis, diarrhea and various digestive troubles, and died; whereas, the control monkeys on natural diet remained in good health. If this observation is correct—and there are no good grounds for a reasonable doubt—the problem of digestive diseases, which forms such a large part of practice, is primarily one of diet, rest, and exercise.

In a study of the patients who consult the internist for relief of indigestion, and who, on examination, are found to have a hyper- or an anacidity of the stomach, also a palpably filled cecum, often more tender after operation than before, and where other possible factors, such as urethral stone, retroverted uterus, ptosed kidney, etc., have been excluded, an attempt has been made to find, if possible, a single factor which could cause this distress. If there is a single factor, its relief should relieve the indigestion. With this in mind, each case with digestive complaints was carefully radiographed in search of a possible cause of the symptoms. With surprising uniformity, delay of twenty-four hours or longer in the cecum and ascending colon has been demonstrated. In those cases which have not shown stasis in the cecum and ascending colon and remained unrelieved by suitable dietary treatment, other pathology to account for their symptoms has been found. There are types of cecum which obviously do not belong in the class under discussion,

[1] This study is being made through the aid of the Selmene Winter Foundation for the developmental study of children. Paper read before the Radiological Society of North America, at Atlantic City, May, 1925.

[2] MAYHEW, J. M.: Appendicitis or What? Neb. St. Med. Jour., 8:265.

LAWRENCE, C. H.: Cause of Recurrence of Symptoms after Removal of Appendix. Boston Med. and Surg. Jour., 189:671-673.

QUAIN, E. P.: Pathogenic Ptosis of the Right Colon. Arch. Surg., March, 1923, 6:638-652.

FINNEY, J. M.: Surgical Aspects of Chronic Intestinal Stasis. Southern Med. Jour., 16:680.

[3] MCCARRISON, ROBERT: Faulty Food in Relation to Gastro-intestinal Disorders. Jour. Am. Med. Assn., Jan. 7, 1922, LXXVIII, 1, p. 1.

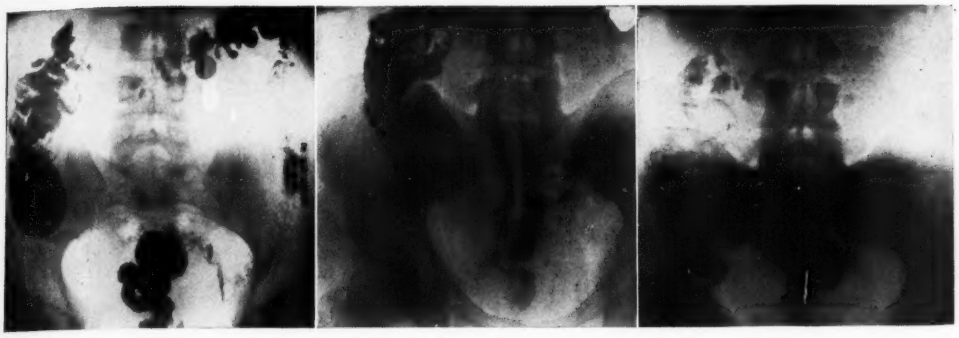

Fig. 1. Fig. 2. Fig. 3.

Fig. 1. Case 1, 24-hour plate of cecum before operation, showing appendix.
Fig. 2. Twenty-four-hour plate of same case as Figure 1, two years after appendectomy. Gastric symptoms unchanged. Cecal stasis larger than before operation.
Fig. 3. Same case as Figures 1 and 2. Forty-eight-hour plate, cecum not empty. Patient relieved by diet and increased elimination of bowels.

namely, the cecum mobile, diverticulitis of the cecum, and a cecum with demonstrable adhesions.

The cases previously operated on for chronic appendicitis without relief of symptoms, who, on physical examination were found to have tender cecums and by the X-ray showed only delay in the ascending colon (which by many would be considered as normal), with no other demonstrable pathology, have done well on diets which tended to relieve this stasis. Encouraged by these results, a few cases which had not been operated on, with the usual symptoms referred to as chronic appendicitis and having cecal stasis as demonstrated by the X-ray, have been placed on similar dietary measures, with gratifying results, so long as they have kept reasonably close to the dietary régime. Those who did not respond were operated upon and definite pathology always found. Practically all cases operated on after an attempted medical cure have done well after operation.

The etiological factors in stasis in the ascending colon and cecum are probably intimately associated with chronic inflammation of the appendix, with ptosis, colitis with spasms of the pylorus, and other allied conditions. Perhaps this stasis is normal and symptoms come from pathological infection. If some stasis is normal, there undoubtedly is a limit to the length of time food can remain in the ascending colon without creating pathological stasis. Certain observations suggest the normal cecal stasis to be still considerably in doubt; it may be well under twenty-four hours. By normal stasis is meant a stasis which is not causing irritation toxicity, mechanical blocking, or pathological change, and is not necessarily an average condition, and may vary with the individual's tolerance.

In order to establish more clearly the onset of these chronic gastro-enterological conditions a study of the infant from birth to adolescence, with special reference to constipation, stasis, chronic appendicitis, ptosis, colitis and ulcers, is being undertaken with Dr. W. W. Wasson. Evidence at hand suggests that many of these conditions begin in infancy, and cures are attempted after such structural changes have taken place as to make permanent good health almost impossible.

With your permission, I beg to raise the question as to how many of the digestive troubles of adult life have their beginning in infancy, and are the result of prolonged, though at times minute, disturbances of physiology. It has seemed to us that the correct solution of this problem can be reached only by a study of the gastro-intes-

tinal tract from infancy to adult life in a given individual. This study is being carried out by repeated X-ray examinations, beginning in infancy with physical and laboratory examinations, clinical history

Fig. 4. Case 2, 24-hour plate of cecum six months after appendectomy. Cecum clear. Gastric symptoms relieved by fixation of retroverted uterus.

and study of environmental conditions and habits. These children are selected from families in all walks of life and living under various conditions.

At the present time the factors which apparently tend to promote stasis in the ascending colon and cecum are: too rapid dehydration of the intestinal contents, probably caused by lack of sufficient water during the day, insufficient roughage in the diet, a poorly balanced vitamin content, insufficient exercise of the abdominal muscles, and the increasing nervous strain and consequent fatigue of modern living.

Gray[4] feels that congenital adhesions and bands are responsible, and it is quite obvious that a retrocecal appendix is probably congenital. Lane[5] asserts that many of these adhesions and bands are due to

[4] GRAY, SIR HENRY M. W.: Effects of Stagnation in the Ascending Colon. Can. Med. Assn. Jour., Feb., 1924, p. 93.

[5] BAINBRIDGE, W. S.: Chronic Intestinal Stasis. Brit. Med. Jour., 1913, 2:1125. Quotes Sir W. A. Lane.

new tension and infection creeping throu distended intestine. It would seem t most of these pathological conditions mi be explained on the grounds of, first, sta and stretching of the intestine; second, l

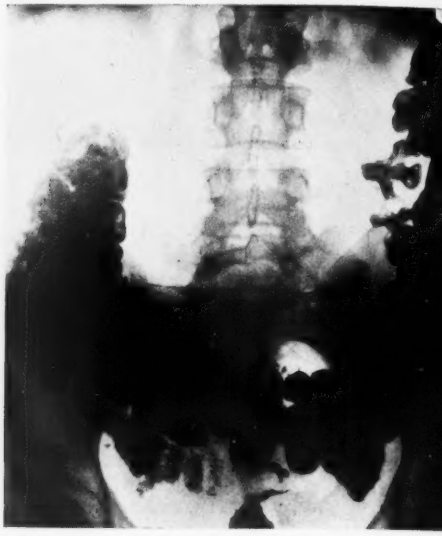

Fig. 5. Case 3, 24-hour plate of cecum and co Appendectomy two years before, without relief of sy toms, ptosis, spasm or stasis.

grade infection creeping through with sulting inflammation; third, the bod natural reaction to inflammation, throwi out fibrinous exudate; and, fourth, ad sions, bands and membranes as a res of organization of this exudate. Such theory would explain the limited numb of chronic intestinal ailments in childho and would throw light on the rather sudd increase of this condition as the respon bilities of life are established, with attendant constipation, insufficient exerc and water, nervous strain and fatigue. is well recognized among pediatricians t the milk of a mother who is nervous a tired produces a colicky, constipated ba and when a mother is calm, rested a relaxed, the infant's digestion becon normal.

When adult patients, whose digesti have been normal without any sympto referable to the gastro-intestinal tract,

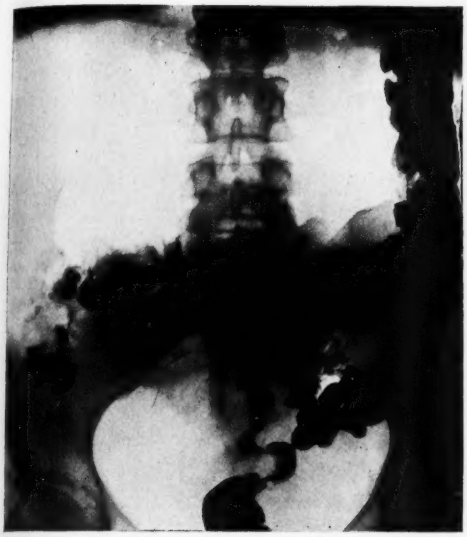

Fig. 6. Same case as Figure 5, showing 48-hour plate of cecum and colon, the latter slowly emptying. Relief secured and twenty pounds gained in weight on diet; partial relief of stasis.

Fig. 7. Case 4, 24-hour plate, showing cecum, colon and appendix (no operation). Relief of symptoms by increasing the elimination of bowels.

gin to have symptoms of indigestion, in the absence of other pathology, the X-ray usually discloses a stasis in the cecum and ascending colon, although the patients say their bowels have moved daily without

Fig. 8. Case 5, 24-hour plate of cecum, colon, appendix (no operation). Relief of symptoms by evacuation, or increased elimination of bowels.

assistance. These cases usually are completely relieved by simple regulation of diet, rest, and sufficient fluids. This type of case, on a restful vacation, is completely free from symptoms. These might be termed the pre-appendiceal type of case.

It is to this group of beginning intestinal invalids that medical treatment should be directed, especially if they can be kept under observation. Their symptoms suggest a chronic appendicitis; they are tender over the distended cecum, and appendectomy may cure or may give them only temporary relief. Unless properly treated medically these cases become surgical, then again medical, while the cecum and ascending colon remain distended and the gastro-intestinal symptoms continue—to the discredit of the profession.

Prophylactic treatment consists in giving two glasses of hot water before breakfast and drinking at least six glasses of liquid during the day. Plenty of vegetables, bran or agar-agar, and whole wheat bread are advisable. If necessary, a level teaspoonful of sodium bicarbonate in water may be taken on arising to assure a thorough

evacuation. Massage, either manual or by vibrator, is helpful. Exercise, such as golf, tennis, swimming, hand-ball, etc., helps. Setting-up exercises every morning consume less time and give good results. Cathartics should be avoided, but, if required, a small amount of magnesia and liquid petrolatum at bedtime is the least harmful.

Lest there be some misunderstanding it may be well to state that no attempt is being made to lay all gastro-intestinal ills at the door of the cecum and ascending colon, or that surgery is not the best form of treatment in the large majority of cases. There are undoubtedly other factors responsible for indigestion, but careful attention to this part of the alimentary tract may save unnecessary operation, and those patients already operated on unsuccessfully may be relieved of a condition which tends to grow worse. We hope in the future to present observations which may help in the solution of some of these factors.

DISCUSSION

DR. L. T. LEWALD (New York): Dr. Cunningham has referred to the difference in the diagnosis between this condition and chronic appendicitis, and I happen to have had two cases which bear on this point with some interest. The first illustrates the duration of retention which may occur in the appendix, whatever its significance may be. Here is a record of *119 days with retention of material in the appendix* (Fig. 1). It finally was found empty on the hundred thirty-ninth day, so that it emptied after somewhere between 119 and 139 days. In another similar case the appendix was not found empty on the hundred thirty-seventh day, but was empty on the hundred seventy-first day. In the first case there was no material visible radiographically in the appendix before the X-ray examination; in fact, there had been a previous examination made by an opaque meal, and an exposure at that time showed no shadows in the appendix. I did not make that particular examination, but from that meal, given by my assistant at Bellevue College, when I saw the case several weeks later I was able to pick up the shadows in the appendix. The first examination was simply a routine twenty-four-hour expo sure, there being no further exposures be cause of the limitation on the study of the case. I would like to ask Dr. Cunningham his opinion as to whether that long reten tion alone would warrant a diagnosis of chronic appendicitis. The patient was more or less tender over the region of the appendix when I first saw her. By the time the appendix was entirely emptied, I could not elicit any tenderness over the appendix so I did not insist on any operative proce dure at the time, but advised operation in case her trouble should return. The other case illustrates a somewhat similar *reten tion in multiple diverticula of the colon*. In this instance the diverticula remained filled *52 days.*[1] Some of the diverticula were on the right side. I believe Dr. Cun ningham mentioned diverticulitis of the cecum and right side as coming in the dis cussion of his paper, so that here is a rec ord of the length of time that material may remain in a diverticulum. The diagnosis previously had been gall-bladder trouble but I think diverticulitis is the probable explanation of this patient's symptoms. In one other case a diverticulum of the colon remained filled on the ninety-eighth day and was empty at the end of 113 days.

DR. W. I. LEFEVRE (Cleveland): There is one little point in the treatment of these cases that I would like to pass on, as it works very well in many of these spastic conditions of the colon. That is, a thor ough dilation of the rectum and sphincter ani, preferably under a general anesthetic I have recommended it many times with satisfactory results.

DR. B. C. DARLING (New York): I would like to ask a question, whether the whole colon must be emptied in twenty-four hours to constitute a bowel movement?

[1] LE WALD, L. T.: Right-sided Diverticulitis. RADIOLOGY, Jan., 1925.

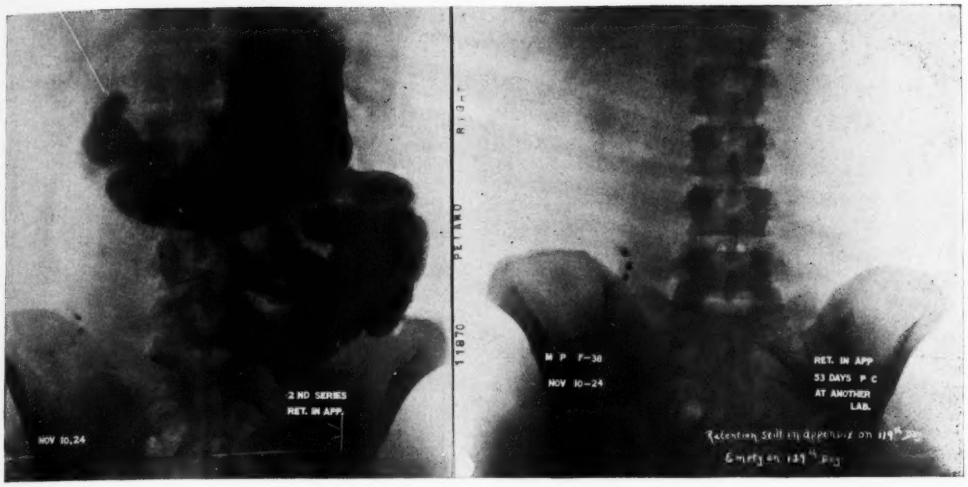

Fig. 1. Case of retention of material in appendix over period of 119 days. (See Dr. Le Wald's discussion.)

notice that the films showed that the left colon was emptied. Just where constipation begins and normal movement of the bowel leaves off, I would like to have made perfectly clear.

Dr. T. D. Cunningham (closing): In regard to Dr. LeWald's case of appendicitis, I think we are inclined to believe that any considerable stasis is pathological, whether in the appendix or the cecum. In regard to the rectum, I think that is a good point about a tight sphincter causing constipation, and it may, in itself, be a predisposing cause of trouble in the appendix, owing to the slowing up of the fecal column. I feel very much as Dr. Darling does on the question of good bowel movement; whether it should be completely emptied in twenty-four hours or not, I do not know. I feel the cases which I have shown you have gained relief by being put on a diet with more roughage and increasing their elimination. Whether they empty the colon every forty-eight hours or only once a week, I do not know, but if it empties a little faster than it has been doing, they seem to obtain relief.

METASTASIS TO THE BONES FROM CARCINOMA OF THE BREAST: A ROENTGENOLOGIC STUDY[1]

By HENRY W. MEYERDING, M.D., Section on Orthopedic Surgery, RUSSELL D. CARMAN, M.D., Section on Roentgenology, Mayo Clinic, and JOHN D. GARVIN, M.D., Fellow in Medicine, The Mayo Foundation, ROCHESTER, MINNESOTA

METASTASIS to the bones from carcinoma of the breast is of great practical interest because of its frequency. The roentgenologic examination is of paramount importance in detecting the condition. Careful interpretation of the roentgenograms often determines operability of carcinoma of the breast, averts fruitless surgery, and enhances the accuracy of prognosis. In view of these considerations, we have reviewed the records of 1,985 cases of carcinoma of the breast examined at the Mayo Clinic during the last six years. In sixty-seven (3.48 per cent) metastasis to the bones had occurred.

Necropsy records, which obviously cannot be compared with statistics of the living, have shown percentages as high as 26.5 (4). In 329 necropsies at Middlesex Hospital, metastasis from carcinoma of the breast was found in seventy-three cases (22 per cent) (3). Matthews quotes Leutzinger's statistics showing that there is metastasis to the bone in 14 per cent of cases of carcinoma of the breast. Müller, in 858 necropsies, found metastasis to the bone in 144 cases (16.5 per cent). Since the bones are rarely all examined at necropsy, the maximal estimate of 26.5 per cent at the time of death is doubtless still too low. As Pfahler suggests, complete examination of the bones with the roentgen ray would probably be more reliable. It is fairly certain, however, that with carcinoma of the breast there is a higher incidence of metastasis to the bones than with carcinoma in any other organ.

Sixty-four of the patients were females and three were males. The average age was forty-eight and seven-tenths years; the youngest patient was twenty-nine and the oldest sixty-seven. The average number of pregnancies was 2.4. The right breast was the primary seat of growth in thirty-five cases, and the left in thirty-one; in one case both breasts were affected. Examination of the urine was negative. The Wassermann test was negative in the sixty-one cases in which it was performed. Symptoms which led to roentgenologic examination were variable pains, referred to the back, hips, legs, and so forth, in sixty-one cases. The pain was usually neuritic, occurred below the site of the affected part, and varied from mild "rheumatic" or "sciatic" to severe and continuous, requiring opiates. Many of the patients did not appear very ill nor had they lost weight markedly. In three cases of the series, fracture from trauma insufficient to produce fracture of a normal bone was the first sign. In two cases there was no reason to suspect metastasis, and it was discovered by the routine roentgenologic examination. A palpable tumor at the site of metastasis was noted in only one case.

The axillary glands were found to be affected in forty cases, the supraclavicular glands in three, both supraclavicular and axillary glands in six, and the chest wall in two, making a total of fifty-three cases (79 per cent) in which there was glandular involvement. In order of frequency the bones involved were:

	Cases	Per cent
Pelvis	26	38
Femur	23	34
Lumbar spine	21	31
Ribs	18	26
Dorsal spine	11	16
Cervical spine	4	6
Clavicle	4	6
Scapula	4	6

[1] Read before the Radiological Society of North America, at Atlantic City, May, 1925.

Sacrum	4	6
Cranium	2	3
Tibia	1	1.5
Sternum	1	1.5

There was multiple involvement of the bone in forty-three of the sixty-seven cases (64 per cent). Joll, in his report on necropsies, names in order the vertebræ, ribs, sternum, and femur as the most frequent sites of metastasis. Williams, quoted by Joll, found the skull invaded in 24 per cent and the vertebræ in 19.01 per cent of the cases examined at necropsy. Ewing places the sternum, ribs and femur before the skull and vertebræ. Handley gives the order as sternum, ribs, femur, and spine. He also says that the sternum and ribs are affected much more commonly than any of the other bones. Risley also holds that proximity to the focus increases the liability and that the sternum and ribs are most commonly invaded. In this series, in which it must be borne in mind that the diagnosis was based on roentgenologic findings in living patients and not on necropsy, the number of cases in which the sternum was involved is negligible, and the ribs were not affected nearly so often as the findings of others would indicate.

When the pelvic ring was affected, the metastatic lesions were about equally divided between the ilium, ischium and pubis, the sacrum being implicated alone in four cases. When the femur was involved the lesion was usually in the upper third. Of the thirty-six cases in which there was metastasis to the spine it was confined to a single vertebra in but four cases, and the lumbar region was involved in 58 per cent. Moore, in a series which included metastasis from various organs, found the lumbar spine affected in 75 per cent, and in no instance was the metastasis limited to one vertebra.

Radical amputation had been performed in forty-six cases, simple amputation of the tumor in three, paste had been used in three, roentgen ray in one, and electricity in one. In fourteen the condition was inoperable and no treatment was given. The effect of radical amputation on metastasis may be inferred from a comparison of the time when metastasis appeared in this group with the time it appeared in cases in which operation was not performed. In the cases in which operation was performed, the average interval between the discovery of the tumor and discovery of metastasis was forty-four and six-tenths months, and in the cases in which operation was not performed, metastasis was discovered after an average interval of seventeen and nine-tenths months. Thus it would appear that efficient surgery has a decided effect in postponing metastasis to bone. The average time between operation and the discovery of metastasis was thirty-one and three-tenths months. In twenty-five cases with definite records, death occurred on an average of four and seven-tenths months after the discovery of metastasis.

Pre-operative radiotherapy was given in but two cases, and the average time of metastasis to bone was twenty months. Post-operative radiotherapy was given in thirty-five cases, metastasis occurring twenty-four and seven-tenths months after operation. In eight cases in which no post-operative radiotherapy was given, the average time was thirty-seven months. On the basis of these data radiotherapy was of no effect in slowing metastasis; indeed, it had the opposite effect. In mitigation of these statistics, mention should be made of the small number of cases in which there was no irradiation, and the fact that it was omitted in the more favorable cases.

The metastatic lesions are commonly of the osteoclastic type, and are characterized roentgenologically by a honeycombed appearance with a marked decrease of density and mottling in the affected areas. Rarely, if ever, is there a purely osteoplastic type, but occasionally there are mixed types. Roentgenologic simulants of metastasis include osteoporosis resulting from disuse, multiple myelomas, osteomalacia, sarcoma, osteomyelitis, osteitis fibrosa cystica, and Paget's disease. A careful analysis of the

roentgenologic findings will go far toward excluding these simulants, but a correlation with the clinical facts is essential for final diagnosis, the most decisive of which is the presence of a tumor of the breast or a previous amputation.

Osteoporosis resulting from disuse presents a true rarefaction without destruction, and, save for thinning due to deficient lime salts, the structure of the bone remains unaltered. Senile porosis is so general in distribution that its cause will usually be obvious.

With multiple myelomas the areas of rarefaction tend to be sharply defined, and are regularly round or oval, presenting a punched-out appearance. Bence-Jones bodies are present in the urine in approximately 80 per cent of the cases, and are a decisive characteristic of the condition.

Osteomalacia is relatively rare, tends to be general and symmetric, produces bowing and distortion of the bones, but seldom fractures, and is characterized in the roentgenogram by an extreme, homogeneous porosis without mottling.

Sarcoma is primary, appears early in life, invades the surrounding tissues, is single and not multiple, prefers the ends of the bones, and sometimes occurs below the elbow or knee. The last named criterion is not absolute; Moore has reported instances of metastasis from the breast to the radius and the phalanges.

The rarefying type of osteomyelitis has some resemblance to secondary malignancy, but the affected bone is widened and irregular in contour, may contain cavities, and practically always shows evidence of a regenerative process. We have observed an instance of osteomyelitis affecting a single vertebra in which the roentgenologic appearance was that of metastasis, as there was no indication of regenerative or inflammatory reaction.

Osteitis fibrosa cystica should hardly be confounded with metastasis, for the cortex is expanded and thinned, but unbroken, large cyst-like areas are present in the medullary cavity; the condition rarely invades the epiphyses, and fibrosis is marked.

Paget's disease is of the osteoplastic type, the skull is often affected, and if the vertebræ are implicated they are flattened and widened.

While this review has elicited no novel facts, it may serve to emphasize again the practical importance of the subject to roentgenologists and clinicians alike. In every case of carcinoma of the breast, and in cases of middle-aged women, with or without a definite history of carcinoma of the breast, who complain of "rheumatic" or "sciatic" pain, the possibility of metastasis to bone should be considered. Since it is impractical to make a roentgen-ray examination of the bones in every instance, much depends on the judgment of the clinician. Moreover, since metastasis may indicate certain other lesions, the roentgenologist should be careful not to overlook it, and in doubtful cases he should co-operate actively with the clinician.

BIBLIOGRAPHY

1. Baetjer, F. H., and Waters, C. A.: Injuries and Diseases of the Bones and Joints. New York, Hoeber, 1921, 241 pp.
2. Carman, R. D., and Carrick, W. M.: The roentgenologic aspects of osteitis deformans, Paget's disease, with reports of fifteen cases. Jour. Radiol., 1921, II, 7-28.
3. Handley, W. S.: Cancer of the Breast and its Treatment. New York, Hoeber, 1922, 411 pp.
4. Joll, C. A.: Metastatic tumors of bone. Brit. Jour. Surg., 1923, XI, 38-72.
5. Matthews, A. A.: Secondary carcinoma of the bone. New York Med. Jour., 1915, CI, 1150-1157.
6. Moore, A. B.: A roentgenologic study of metastatic malignancy of the bones. Am. Jour. Roentgenol., 1919, VI, 589-593.
7. Pfahler, G. E.: The roentgen diagnosis of metastatic malignant disease of the bone, with especial reference to the spinal column. Am. Jour. Roentgenol., 1917, IV, 114-122.
8. Risley, E. H.: Skeletal cancer. Boston Med. and Surg. Jour., 1915, CLXXII, 584-587.

DISCUSSION

Dr. W. P. Whittington (Asheville, N. C.): I have been much interested in Dr. Carman's paper and it has suggested several things to me. I wish to report the results in the first case of cancer of the breast I ever treated with X-ray, over

twenty years ago, when I received my first old static machine with X-ray apparatus and attachments. I had a patient who consulted me about the time I was placing the order,—a woman who had had a cancer of the right breast for about four years. The whole breast had sloughed away. The woman was cachectic, had lost twenty pounds in weight, and was a picture of that progressive condition you find in those neglected cases. There was a filthy and offensive discharge from the breast, and so far as surgical methods were concerned, the case was hopeless. When my X-ray machine arrived (I had never operated a machine before), I had the patient come in and I began treatments. This part of the report will illustrate some of the discussion as to the quality of the rays used. Without a meter or any kind of method of determining the wave length or the dosage or anything else but that we were throwing X-rays on this woman's breast, I began the treatment. The way I determined the strength of the current was by the shadow of my hand before the X-ray tube. I gave these treatments at a distance of ten inches, ten to fifteen minutes, every other day for two or three weeks. Then twice a week, and in a short time the ulcer began to get better. The discharge disappeared, healing began and in two months that woman's breast was completely healed. There had been axillary glands as large as a hen's egg. They almost entirely disappeared. The woman began to improve in general health, regained her twenty pounds, and was soon in as good condition as she had been six years before. She went on in that condition for four years of complete recovery, with a useful and happy life. But after the end of four years, she began to complain of pains in the spine, in the dorsal region. They became worse and worse; she became drawn over, constricted, suffered a great deal of pain from metastasis to the spinal column, and in about a year's time died with a great deal of pain. Now, gentlemen, you can construe this in any way you please; whether we should give deep X-ray, superficial X-ray, small dose or large dose and by what method we should give it. The doctor has set forth the fact of metastasis to the bony tissues of different parts of the body.

Dr. L. T. LeWald (New York): Dr. Carman has called attention to Paget's disease as one of the conditions liable to be mistaken for secondary carcinoma, in differential diagnosis, and I called attention to this possibility in a paper before the Mississippi Valley Medical Society in 1916. I wish to report a case of Paget's disease in which the pelvis is involved, and the upper end of the femur, the iliac bone and the lumbar spine. Now in this particular instance there were other places in which the disease was manifest, that is, the cranial bones did show it and there was quite a marked lesion in the humerus, but I have seen other cases in which the criterion of cranial involvement was lacking. I will now report a case of Paget's disease in which the tibia and the lower end of the femur in particular show the characteristic lesions, but the *skull is devoid of any evidence of Paget's disease and likewise the pelvis is negative.* One roentgenologist has suggested that the pelvis may be taken as a criterion in the diagnosis of Paget's showing in other bones, rather than the skull. Here is an instance that I feel is a Paget, which shows *neither* involvement of the skull *nor* of the pelvis, so we have neither of these criteria to guide us in the diagnosis. I have had two cases within a week or so in which pain in the back led to an X-ray examination. In the first case definite characteristics of secondary bone involvement were present, and I sent the patient back to the clinician, who found a *tumor in each breast* which had not been recognized previously. The other case is one in which I believe there is a manifestation of secondary carcinoma in a woman 53 years of age, but in which no primary lesion at the present time has been demonstrated.

COMPRESSION FRACTURES OF THE SPINE[1]

THEIR X-RAY CHARACTERISTICS AND DIFFERENTIAL DIAGNOSIS

By L. R. SANTE, M.D., F.A.C.P., Associate Professor of Radiology, and LEX G. McCUTCHEN, M.D., Assistant in Radiology, St. Louis University Medical School

From the Radiology Departments of St. Louis City Hospital and St. Mary's Hospital

COMPRESSION of the body of the vertebra is a relatively common injury. This type of injury comprised 40 per cent of the total number (400) of spinal injuries treated at the St. Louis City Hospital, St. Mary's Hospital and Infirmary during the past five years.

Injury to the spine is sustained by a sudden application of unusual force to the anterior portion of the vertebral body from forced flexion. This force may be applied at either end of the spine, causing it to buckle, as, for instance, when an individual falls from a height and lands on his feet or buttocks, or where a heavy weight drops on his shoulders; or it may be applied to both ends of the spine simultaneously, for instance, when an individual is caught between two railroad cars. Whatever the character of the accident, this type of injury is the result of forced flexion on the spine.

The conformation of the spine is somewhat different from other bones, as it acts as a housing for some of the most important structures of the body, that is, the cord and its attendant nerve trunks, and it is one of the strongest structures of the body. The construction of the vertebræ themselves and the spinal column as a whole predisposes to this type of injury, as the bodies of the vertebræ are composed of cancellous bone and are thus poorly protected anteriorly against forcible flexion of the spine, and the normal spinal curves produce weak points in its construction, making it more susceptible to injury. Posteriorly the pedicles and articular processes are composed of compact, dense bone and afford a much stronger support.

Among the spinal injuries observed by us, the most frequent was in the upper lumbar region, the lower dorsal ranking next, then the lower cervical region. It is interesting to note that these fractures occur sometimes when the site of the injury is very slightly involved. Eighty per cent of all compression fractures of the spine occur in the lower dorsal and upper lumbar region (between the tenth dorsal and the third lumbar). While the lumbar vertebræ are the largest and strongest, injuries to their bodies are to be expected more frequently since they are the most cancellous in character and bear a greater weight than the dorsal or cervical. They are also capable of considerable flexibility, but have feeble supporting walls.

Radiographically, this injury is characterized by compression of the vertebral body, either at the anterior or lateral margin. The cancellous portion of the bone is compressed, but the interarticular cartilaginous disc is elastic and incompressible, and, because of this, the deformity resulting from an injury is readily detected. Where the compression of the body is at all pronounced the smooth curve of the spine is lost and definite angulation is produced, even to the extent of a kyphosis or scoliosis. Both anterior-posterior and lateral views of the spine are necessary for a diagnosis. In the anterior view, the body of the compressed vertebra is narrowed and may or may not be perceptibly broadened. If the width of the bodies is compared by drawing horizontal lines through the articular margins of the vertebræ, a definite disproportion is usually found. Normally, from above downward, the bodies of the vertebræ become successively larger, but this variation in width is uniform and in

[1] Read before the Radiological Society of North America, at Atlantic City, May, 1925.

the same direction, and any disturbance of this normal relationship by the interposition of a narrowed body should be easily

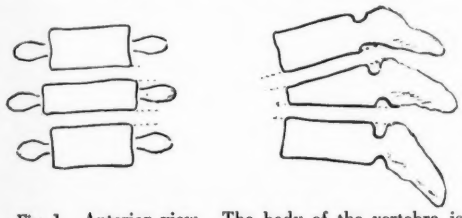

Fig. 1. Anterior view. The body of the vertebra is narrowed and may or may not be perceptibly broadened. Compare width by drawing horizontal lines through the articular margins.

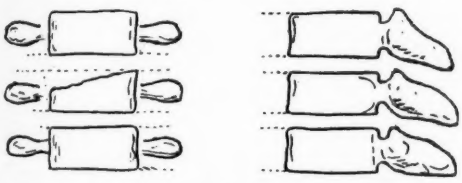

Fig. 2. If only one margin is compressed the lateral view may appear perfectly normal.

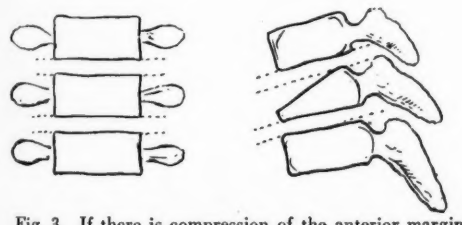

Fig. 3. If there is compression of the anterior margin and downward rotation, the anterior view may not show the lesion.

detected. The deformity is most frequently seen in the lateral view, the compressed anterior margin of the injured body producing a deformity suggesting "a piece of pie" in shape, which results in an angulation of the spine, and kyphosis. Both anterior-posterior and lateral views are essential, however, since conditions may arise in which the X-ray may not show the deformity in one of the views. For instance, if only one side of the vertebral margin is compressed, the lateral view may appear perfectly normal. Likewise, if there is compression of the anterior margin and downward rotation, the anterior view may not show the lesion (Figs. 1, 2 and 3).

Compression fractures heal by outgrowth of bone, or exostosis, from the vertebral margin of the injured and adjacent vertebræ, which is Nature's effort to immobilize this segment of spine. This new bone formation may not be apparent for several months after the injury, but regardless of the length of time it may take for a complete ankylosis to occur, the interarticular discs remain intact—a differential point worthy of note. This type of fracture rarely occurs in children, and is most common in males between the ages of twenty and forty, because of their more hazardous and active occupations. Fractures in the cervical region also include those of the articulating pedicles of the vertebræ, and allow a posterior angulation. Compression fractures of the spine must be differentiated from the following conditions:

1. Tuberculous spondylitis.
2. Hypertrophic spondylitis.
3. Pyogenic infections of the spine.
4. Charcot's spine.
5. Malignant involvement.
6. Pressure destruction of the vertebræ.

Tuberculosis. In tuberculosis the collapse of the vertebral bodies is due to bone destruction. This process starts at the disc margin of the body and spreads, to involve the interarticular disc. In the first stage of the disease the lesion can not be recognized by the X-ray, because the disc retains the articular space. When there is destruction of the body and obliteration of the articular space it may then be recognized by the X-ray. In tuberculous lesions there is very little, if any, new bone formation; thus, healing is never by bone production unless secondary pyogenic infection has taken place. There is usually a posterior angulation and a fusing of the bodies of the vertebræ, which is due to the anterior border of the spine becoming softened, then crushed by the weight of the body into a wedge-shaped mass, resulting in the characteristic kyphosis.

Normally, in young individuals, there is a definite narrowing of the anterior margin of the body, and, at times, a definite irregularity. A line is sometimes seen extending transversely through the body of the vertebra in the thoracic region, resembling an epiphyseal line. This is a feature of normal development and should never be mistaken for pathology. Normally, in older individuals, there is frequently a cupping in the middle of the body with an appearance which may resemble a compression fracture; or there may be a rounding of the back which, though normal, may be very suggestive of a compression fracture. It must be borne in mind, however, that such cupping or narrowing of the vertebral bodies represents atrophy of the bone, physiological in old age, and the narrowing is seen in the lateral view to be in the middle of the vertebræ, rather than at the anterior margin, and always involves more than one vertebra; also, the dorsal curve is uniform and rounded, not abrupt and angular as in compression fractures. With the complete destruction of the interarticular discs and the fusion of the bodies of two vertebræ from the tuberculous process, the resulting mass may assume a wedge-shaped appearance resembling a compression fracture. Close inspection will show, however, that the posterior portion of the body is much wider than the width of any of the uninvolved bodies—in fact, almost twice the width—and two spinous processes will be seen projecting posteriorly, which establishes at once the character of the lesion as a healed tuberculous process. Tuberculosis here, as elsewhere, heals by replacement of destroyed bone tissue with fibrous tissue and not new bone; with secondary pyogenic infection, however, new bone formation may appear. Occasionally tuberculosis develops after injury. In one instance particularly this was noted. First, the definite wedge-shaped deformity with preservation of the interarticular disc, followed by a tuberculous process, which over a period of years destroyed the disc and vertebral body and finally resulted in the formation of a tuberculous abscess.

Pyogenic Infections. Pyogenic infections other than those associated with tuberculous involvement are very rare. No definite instance of acute osteomyelitis of the vertebræ has been encountered. Pyogenic infection associated with post-typhoid infection has been observed, and in this case there was no narrowing of the vertebral body, but apparently a growth of new bone invading the disc, causing ankylosis of one or more vertebræ without loss of substance and without affecting the vertebral width.

Hypertrophic Spondylitis. Hypertrophic spondylitis may be so severe and the bony exostosis so heavy as to be mistaken for the healing stage of compression fracture. In arthritis of the spine there is no periarticular swelling or joint effusion, because of the rigidity of the ligament and the thickness of the surrounding muscles. The process is recognized chiefly by bone production and little, if any, bone destruction. The articular cartilage may be destroyed, yet the space will not be narrowed because of the intervertebral discs holding the bodies apart. One may have a very painful and rigid back, which is negative to the X-ray. Several months later it will be indicated by exostoses on the margins of the spine. The first change noted by the X-ray is a flattening of the margins of the vertebræ where the lateral ligaments are attached. Later, exostoses will form along the body margins, which always point towards the adjacent bodies. This process may continue until the bodies of the vertebræ are completely fixed, a condition associated with a marked anterior bowing. When this state is reached, practically all the ligaments have become calcified. Usually, however, where compression fracture is the exciting cause, exostosis is limited to the involved vertebræ, the remainder of the spine being free.

Pressure Necrosis. Pressure necrosis of the vertebral bodies from pressure of a tumor mass, such as an aneurysm, while

it does cause a loss of substance in the vertebræ, usually in the thoracic region, does not present a wedge-shaped appearance of the bodies and should not be mistaken for injury. The pressure defect is located on the anterior surface of the bodies of the vertebræ, and the amount of involvement depends upon the size and location of the aneurysm.

Charcot Spine. Charcot spine may in its beginning very closely resemble compression fracture of the spine. Later, however, the discs become more or less destroyed and there is an over-production of new bone, with destruction of the body, producing an angulation and deformity with much bony detritus about the bodies of the destroyed vertebræ. The sclerotic appearance of condensing osteitis, associated with Charcot spine, is often of great value in determining the diagnosis.

Secondary Malignancy. Secondary malignancy involving the vertebral bodies is of two general types: The condensing, or osteoblastic, type, characterized by increase in bone density, either in small areas or involving the entire body (this type could hardly be mistaken for injury), and the osteoclastic type, showing small rounded areas of destruction which coalesce and may cause destruction of the body. Where this occurs, however, the destruction is irregular, never producing the homogeneous appearance of a compression. Tumors of the bodies do not extend to involvement of the cartilage, consequently the joint space is intact and there is no angulation or deformity until the condition is in an advanced stage. In cancer of the prostate, the stroma predominates, and in such cases we have the condensing type of secondary lesions. In Paget's disease, there is a slight widening and flattening of the vertebræ, which are symmetrically enlarged. The body appears much denser, due to condensing osteitis. The intervertebral spaces are not involved, and thus the joint space remains intact. If the skull shows the pathognomonic changes of Paget's, that is, increase of density of the inner table and the finely porous and thick outer table, the diagnosis of Paget's disease is certain.

DISCUSSION

DR. B. C. DARLING (New York): The paper showed thorough preparation and was comprehensive and interesting all the way through. There are two points I would like to make. If I heard correctly the paper mentioned the case of a compression fracture five years before where there was slipping and proliferation at the site of two discs. Am I right? Now, it is the general opinion that where you have localized reaction of that sort, it means a previous compression fracture. I want to question that, because it is important in compensation cases. I think that you could have a lesion, like an osteo-arthritis of the spine, localized at the site of one disc or focused in a body,—a tubercular spine that had a proliferative and productive bony deposit. In a similar way, I think that any destructive agent, aside from tuberculosis, can produce those conditions. There is no reason why you need to have half a dozen of them; one is enough. In the case he showed, I think it is questionable whether that was a compression fracture, because he had it at the site of two discs and he did not produce a lateral view, and I do not think he proved his case. I do not think these men who claim that localization of that kind always indicates compression fractures, are right. There is another thing that is collateral to this. The orthopedic men like to put on spine grafts—we are doing it quite a lot around New York. I do not see that the compressed bodies during any stage of softening and repair and going on to the re-deposit of bone—I do not see that they continue to soften down and increase the deformity. The muscular reaction to pain or the mechanism and balance of the posterior articulations of the spine, I think, largely take care of any threatened compression that takes place, and if the spinal inlays are put on only to prevent further compression of these bodies, the course of

compression, as I have seen it, does not warrant the graft. For that reason, if there is localized pain, and you want to stiffen up the spine and are willing to have a stiffened spine, then the graft is indicated. Of course, from the compensation point of view, a man who has a stiffened spine or a compression fracture that he complains of before the settlement is disabled for life; so, from the point of view of compensation, the case is not advanced very much, owing to a permanent stiffening disabling the spine.

DR. L. T. LEWALD (New York): I would like to repeat what I said in discussing Dr. Carman's paper in regard to Paget's disease and not having any development of changes in the skull sufficient to recognize as a diagnostic feature. The interesting case shown just now of a localized lesion in a vertebra might possibly have a counterpart in Paget's disease without any skull involvement, and I think it is necessary to keep that in mind. I have studied 42 cases of Paget's and I have two or three cases in which the lesion is absolutely *localized to one bone.* I have not, however, seen a case where it is localized to one bone in the vertebral column, but I think that might occur.

DR. W. I. LEFEVRE (Cleveland): I want to congratulate the Doctor on his presentation. I am especially interested, as I have in preparation a paper on a similar topic to be presented at our local Academy next Fall. I think we should emphasize one point the Doctor mentioned and that is the importance of including the entire pelvis in films of the lower spine. Then if the patient is twisted or not lying flat on the film it can be detected and not diagnosed as a "curvature" or "rotation," as sometimes happens, especially in medico-legal cases.

DR. C. E. PIERSALL (Reno, Nevada): I think it is just as important to take a stereoscopic film of the pelvis to determine a sacro-iliac lesion as it is to take an anterior-posterior and a lateral in locating a foreign body. In this way the relation of the pubic bones at the symphysis can be determined. A discrepancy there is much greater and more easily seen than at the sacro-iliac joints.

SARCOMA COMPLICATING OSTEITIS DEFORMANS: A REPORT OF TWO CASES [1]

By JOHN D. CAMP, M.D., Assistant Roentgenologist, Massachusetts General Hospital, Boston, Mass.

THE development of bone sarcoma in individuals afflicted with osteitis deformans or Paget's disease of bone has been noted by various observers. Paget in his earliest communication concerning this disease mentions the tendency of such patients to develop malignant conditions. In his subsequent contribution five of the eight original cases which were traced to death had developed malignant disease of one sort or another. The literature from that time contains isolated reports of malignancy superimposed on osteitis deformans.

Packard, Steele, and Kirkbride, in reviewing the literature up to 1901, computed the cases of Paget's disease associated with malignant disease at 7.5 per cent. Da Costa, in 1914, collected 213 cases of osteitis deformans, 9.5 per cent of which had developed malignant disease of some form. It is doubtful if malignant disease not associated with bone should be considered in this computation. A review of a number of these cases reveals that in some instances malignancy was reported when the pathologic finding was that of giant-cell sarcoma. In the absence of further data to prove malignancy and in view of our more recent knowledge concerning giant-cell sarcoma, now known as giant-cell tumor, it is probable that a number of these cases can be removed from the malignant group. Nevertheless there still remains a sufficient number of such cases to warrant the possibility of malignancy in any case of this kind. At least, it is a feature to be borne in mind when considering the prognosis of this disease.

Delafield believes that the incidence of sarcoma in Paget's disease is no greater than is found in any group at that age. The development of sarcoma in patients known to have had osteitis deformans for a number of years lends weight to the theory that the conditions are not inter-related. On the other hand, the chronic changes in the bones and marked disturbance in cell activity have been cited as possible causes for malignant degeneration.

Fig. 1. *Case I.* Right femur, showing normal appearance of the bone and marked calcification of the femoral artery.

The two following cases, observed in the Massachusetts General Hospital within the last year, are reported because of the rather localized changes present in one and the extensive involvement observed in the other.

Case I. A white male laborer, 70 years of age, entered the hospital October 1, 1924, complaining of swelling and pain in the left thigh, of one month's duration.

[1] Read before the New England Roentgen Ray Society, February, 1925.

Three months previously he had fallen from a mowing machine and felt something give way in the left thigh. He experienced some pain on walking but continued to work until one month before admission,

Fig. 2. *Case 1.* Left femur, showing cortical thickening, mottling, with areas of increased and diminished density. Proliferative changes, with well defined ray formation on the medial aspect of the bone projecting into the soft tissues. Marked calcification of the femoral artery.

when swelling began and the pain became constant and increased in severity. He had lost a great deal of weight in the last few months.

The past history disclosed nothing of note except typhoid fever at about 25 years of age, following which the left leg was swollen and painful for two months, during which he used crutches to get about.

The physical examination showed an elderly man with signs of considerable weight loss. In the lower end of the left femur there was a fusiform swelling over an area of about six inches. There was no redness, but local heat appeared to be increased. Flexion and extension of the knee joint were limited and motion was

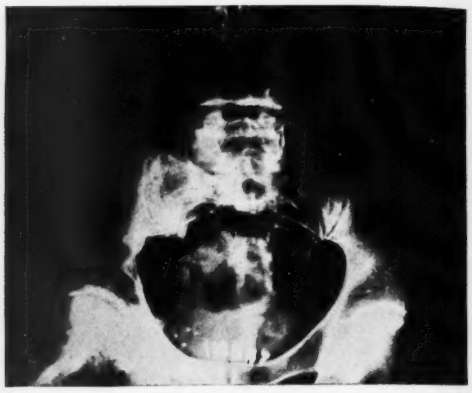

Fig. 3. *Case 1.* Film of pelvis, showing involvement of upper end of the left femur. Involvement of the pelvis just below the left acetabulum is not shown clearly in print.

painful. The veins over the swelling were dilated and tortuous, and the skin tense and shiny. There was no edema below the knee joint and no palpable inguinal glands or abdominal masses.

The temperature was normal and the urine essentially negative. The hemoglobin was 80 per cent; red cells 3,808,000; white cells 10,200; neutrophiles 88; large lymphocytes 3; small lymphocytes 8, and basophiles 1 per cent.

Roentgenograms of the right femur showed no definite variation from the normal (Fig. 1). Marked calcification of the femoral artery was present. The left femur (Fig. 2) was definitely increased in size, showed much cortical thickening and areas of increased and diminished density throughout the greater portion of the shaft. Extending into the soft tissues from the mid-posterior surface were areas of increased density with definite ray-like formation. The process appeared to be almost wholly confined to the left femur, although the film of the pelvis (Fig. 3) showed, just below the left acetabulum, a

small area of mottling, which it was thought might represent a similar process. Films of the skull, hands, and tibiæ showed no definite variation from the normal. A film of the chest revealed no areas suggesting metastases. The roentgenologic diagnosis was that of osteogenic sarcoma of the left femur superimposed on Paget's disease.

Fig. 4. *Case 2.* Lumbar spine and pelvis, showing mottling and increase in density of vertebræ and right ilium.

A clinical diagnosis of Paget's disease, with osteogenic sarcoma, was made. The patient was seen in consultation by Dr. E. A. Codman, who agreed with the diagnosis and the suggestion that roentgen radiation be carried out. Accordingly the patient was given short wave therapy through two 10 x 15 cm. fields, with a full E.D. to each area, in divided doses (½ E.D. at each sitting). No immediate reaction to the treatment was noticed, the pain was not diminished and the tumor was not reduced in size. The patient was advised to return in six weeks for observation, but as yet has not been heard from.

The roentgenograms are interesting in as much as the primary disease appears to be localized to practically one bone—

Fig. 5. *Case 2.* Cortical thickening and characteristic mottling and trabeculation of the right humerus.

a rare distribution of the changes in osteitis deformans. The coarse trabeculated appearance of the femur is quite characteristic of Paget's disease and such an appearance could hardly be produced by bone sarcoma alone. The localized increase in density of the shaft with ray-like areas projecting into the soft tissues, with soft tissue swelling, are quite characteristic of osteogenic sarcoma. If the mono-osteitic or localized type is to be considered, as it is by many, a very early form of Paget's disease, and sarcoma a development from the chronic process, it is interesting in this instance that the malignant condition developed so soon.

Case II. A white male mechanic, 60 years of age, entered the hospital January 7, 1925, complaining of swelling and se-

vere pain in the left arm and shoulder. The pain had begun four months previously in the left forearm, and gradually extended up the arm to the shoulder. It was constant, aggravated by motion, and

Fig. 6. *Case 2.* Mottled appearance of left humerus, with erosion of bone below surgical neck and pathologic fracture. Large soft tissue tumor.

gradually increased in severity. A local physician had made a diagnosis of "neuritis" and advised external applications. These were continued without relief by two other physicians until about one month before admission, and all the teeth had been removed in the meantime for the supposed condition of "neuritis." At this time eight electrical treatments were given by a travelling specialist. The swelling had now increased and the pain was very severe, making it necessary for the patient to give up work. Another physician was consulted and an X-ray examination made. The patient was told that he had some trouble with the bone and was given some medicine "to dissolve it." The tumor was now increasing rapidly in size and he had lost about 30 pounds in weight. As no relief was ob-

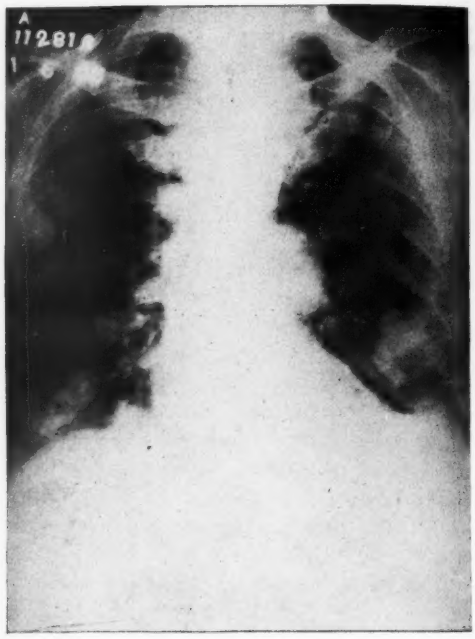

Fig. 7. *Case 2.* Roentgenogram of chest, showing multiple areas of metastases in lungs and small amount of fluid at the left base.

tained another physician was consulted, who referred the patient to the hospital with a diagnosis of sarcoma of the head of the humerus.

The physical examination revealed a man of about sixty years of age sitting up in bed complaining of pain in the left arm and shoulder. He appeared to be well nourished but showed signs of a recent loss in weight. A dry, hacking cough was present. Local physical examination showed a large, tense, brawny swelling of the left upper arm and shoulder. The local blood vessels were prominent, motion was exceedingly painful, and the scapula moved with the humerus. No enlarged glands were noted. Auscultation of the chest revealed moist râles in the upper two-thirds of the

left lung. Abdominal and rectal examinations were negative.

The urine examination, including a Bence-Jones test, was negative. The hemoglobin was 90 per cent; red cells 5,032,000; white cells 18,450; neutrophiles 71; small lymphocytes 26; large lymphocytes 2, and basophiles 1 per cent. The temperature on admission was 101; it rose to 102½ and was normal on discharge five days later. Frequent narcotics were required for the relief of pain.

Roentgenograms showed the bones to be large and the margins rough where the muscles were attached. The arteries showed rather extensive calcification. The right innominate bone showed an increase in size and density, with a rather characteristic mottled appearance (Fig. 4). The lower lumbar spine was more dense than normal. In the upper third of each humerus (Fig. 5) the bones were increased in size, showing coarse irregular trabeculation and considerable mottling. About the left humerus was a large soft tissue tumor. The bone was eroded beneath it and a pathologic fracture extended through the shaft below the surgical neck (Fig. 6). The right tibia appeared wider and more dense than the left. Films of the skull and hands were negative. A film of the chest (Fig. 7) showed multiple round dense sharply defined masses, characteristic of metastatic malignant disease, scattered throughout both lung fields. The outline of the diaphragm on the left was somewhat irregular and the costophrenic angle was obliterated, suggesting a small amount of fluid.

The clinical diagnosis was based on the roentgenologic findings. The prognosis was considered hopeless and the patient was discharged five days after admission.

The roentgenograms in this instance are interesting in as much as they reveal a rather diffuse bone involvement, the usual picture of Paget's disease, and well advanced malignant disease, as evidenced by the metastases in the lungs. The possibility of explaining the entire picture on the basis of metastatic malignancy was considered. However, if such is the case, it is evident that we are dealing with two different types of metastases—the destructive and the hyperplastic. Such a combination in the same individual, while it does occur, is not common. For this reason and particularly as no primary source of malignancy could be demonstrated the diagnosis of osteitis deformans with superimposed sarcoma of the left humerus seemed justified.

GYNECOLOGICAL CLINIC OF THE UNIVERSITY OF ERLANGEN: RESULTS OF X-RAY THERAPY

STATISTICAL REPORT OF 800 CASES OF CARCINOMA OF THE UTERUS

By HERMANN WINTZ, M.D., Ph.D.

TRANSLATED FROM GERMAN BY M. L. MAERZ, M.D., AUGUSTA, ME., AND H. A. JARRE, M.D., DETROIT, MICH.

SINCE my radiation technic has been systematically employed in all cases of carcinoma of the uterus which have come to our clinic for treatment during the past eight years, I feel justified in presenting my experiences to general criticism, in this extensive report. I will first give a statistical account of cases treated which I consider of value in such a report. A detailed analysis, I believe, will show the value of X-ray therapy. I will leave it to the reader to determine if I have been able to demonstrate the value of radiation.

The technic of treatment of carcinoma of the uterus has improved from year to year during the past eight years, until it has reached the state which I have described in my book.[1] May I be permitted to touch briefly on the principal facts? The principle of the technic, which has been elaborated in conjunction with Dr. Seitz, lies in the necessity of radiating the entire carcinomatous area with a single dose, which we designate the "carcinoma dose." In terms of the biological dosage this amounts to 100 per cent of the skin erythema (S.E.D.). In this connection we wish again to point out that the S.E.D. represents a dose which has been determined by means of measuring instruments, and approximately corresponds to that average dose which, in the majority of patients, produces slight reddening in from eight to ten days, and delicate tanning in about four weeks. Our so-called S.E.D. has been determined by means of our electrometric instruments. It is always checked by means of a standard radium preparation. We use 100 per cent of the S.E.D. as a unit. In speaking of the carcinoma dose, I am fully aware of the fact that I have aroused the opposition of many radiologists; but it was necessary to place the radiation technic on a firm basis, just as one speaks of maximal and minimal doses in pharmacology. It was only after hundreds of measurements that we found that there exists among the carcinomata of the cervix uteri themselves as little difference in sensitiveness as there is between the cervical and mammary carcinoma (medullary carcinoma). It has been shown that 90 per cent of the S.E.D. is sufficient to cause a complete repression of these carcinomata. The pronouncedly glandular carcinomata are not quite so radio-sensitive, but in our extensive experiments we have not seen a single case which needed more than 115 per cent of the S.E.D. In this connection I wish to emphasize again the fact that by the term "carcinoma dose" I understand only such an amount of rays as, without fail, causes the disappearance of the carcinoma. That this dose is entitled to this name we can prove by the prompt reaction which we observed in from four to eight weeks in all cases of carcinoma of the cervix in which the dosage had in every respect been accurately carried out. But the carcinoma dose is not in the least concerned with the cure of carcinoma; the cure of carcinoma depends upon many other factors, especially those of a biological nature. A grave mistake was made by various prominent investigators in confusing the destruction of a local carcinoma with a bodily cure and in making the disastrous assertion that a carcinomatous tumor could be caused to disappear and the body be cured from carcinoma by means of small doses. In spite of all efforts to see such a case, I have

[1] Wintz, Hermann: The Radiation of Carcinoma of the Uterus. Thieme, Leipzig, 1924.

not been able to find one during my own experiments, nor have I observed any unquestionable cases in human beings anywhere else. It is to be noted that we are dealing with the assertion that the result

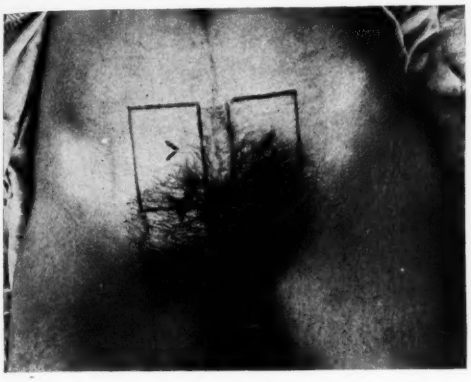

Fig. 1. (See text, page 502.)

was obtained with a really *small* dose, and not with the summation of small doses. It is not inconsistent with my conception of the carcinoma dose, if somebody, instead of applying 110 per cent of the S.E.D. at one sitting, uses 15 per cent or 20 per cent of the S.E.D. for twenty to fifty treatments. It is logically conceivable that in distributing the total dose over a period of time, a larger amount of radiation will have to be used in the end, for the effect of the repeatedly applied small doses is diminished because of the recuperative power of the cell. Thus, if I adhered to the carcinoma dose as the basis of my radiation technic up to the present time, I did so on the ground of accurate measurements and clinical observations. Only those measurements which are made under identical conditions with mine, permit a comparison and discussion regarding them.

But to distribute the carcinoma dose over the entire pelvis is not always possible. It was totally impossible to do so up to the year 1919. With the improvements in X-ray apparatus and tubes during the last four or five years, the attainable percentage of the deep X-ray dose has been so increased that one can at least penetrate the pelvic cavity at one sitting in thin and moderately stout women. Experiments performed four years ago have shown that a distribution of the radiation dose to the

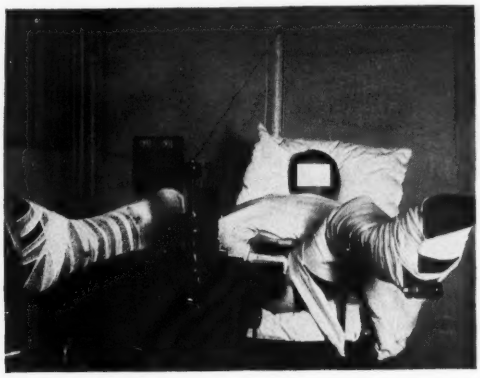

Fig. 2. (See text, page 502.)

uterus in two sittings yields better results, probably because the total damage thus produced is not so great. I, therefore, continue to adhere to the principle of primarily applying to the cervical tumor and the corpus uteri, respectively, a dose of 100 per cent of the S.E.D., concentrating from five to six fields of incidence. This is followed in eight weeks by the radiation of the parametria at one sitting. Prior to 1920 we divided the radiation of the parametria into two sittings, so that we treated the right parametrium six weeks after the radiation of the primary tumor, and the left parametrium after another six weeks' interval.

The principal objection to this method is that it does not meet the demands which are required for the radiation of carcinoma, because a period of six to eight weeks is lost prior to the radiation of a carcinoma which already shows parametrio-infiltration at the first examination. The radiation of the primary tumor, however, apparently arrests the growth of the carcinoma in the glands; I am unable to give a satisfactory explanation for this, but statistics have shown that the distribution of the dose over two sittings yields better results than a sin-

gle radiation of the entire pelvis with the carcinoma dose.

The accompanying photographs illustrate the technic. We use a compression tube 6 × 8 cm. The distribution of the

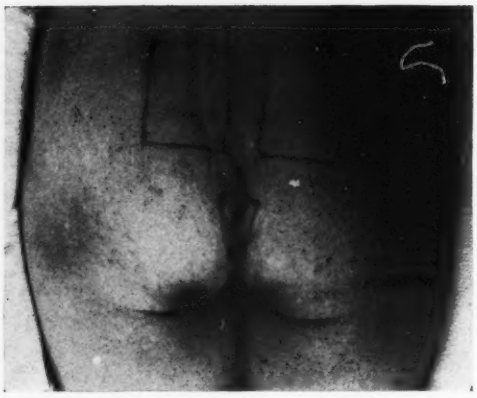

Fig. 3. (See text, page 502.)

different cones is represented in Figure 1. The small area over the vulva is radiated at an angle of about 45 degrees, so that the patient is placed in the gynecological position, and the direction of the beam of rays is toward the vagina (Fig. 2). Figure 3 shows the corresponding areas from behind. The area outlined over the coccyx (coccygeal area) is focused on the examining finger. The direction of this cone is shown in Figure 4. The localization of the areas of radiation designated for the parametria is represented in Figure 5. Figure 6 shows the corresponding arrangement from behind; Figure 7 from the side.

A systematic after-care, as I have fully outlined in RADIOLOGY, October, 1923, page 74, is of importance for the ultimate success of the treatment. I shall, therefore, refrain from going into details in regard to it here.

I shall have to explain the system of statistics more explicitly. The problem of statistics was exhaustively discussed at the Gynecological Congress in Heidelberg and in the publication connected with it. Winter, of Koenigsberg, considered it his task in life to establish systematic principles of statistics in regard to carcinoma of the uterus, based on his experiences of many years. However, even Winter's efforts did not result in formulating statistics which do full justice to the problem. In order to

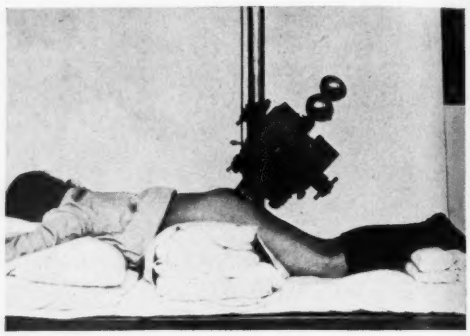

Fig. 4. (See text, page 502.)

fulfill the requirements of the principles of statistics, one can only compare equals. But among one hundred cases of carcinoma there exist just as many slightly different varieties. The continuous improvements in the technic of radiation during the past years have given rise to further differences. Even the largest survey of cancer patients could not be sufficient for the necessary statistical subdivisions without being split into a series of smallest groups. Satisfactory statistics can be collected only in a large clinic which has, within a comparatively short period of time, thousands of cases at its disposal for statistical purposes.

The basic principles of Winter's statistics are as follows:

The entire material is to be included in the statistics. No special subdivisions should, at first, be made, but the total number of cures should be compared with the total number of cases. Later on in these discussions I will show that, in determining the success obtained with a certain method of treatment, it is absolutely essential to make subdivisions, because the proportion of the number of cures to the number of cases treated is much more dependent on the extent and condition of the carcinoma than on the method of treatment employed.

In the following pages I am, first of all, presenting a group of statistics which strictly adheres to the principles generally accepted at the Gynecological Congress in Heidelberg, and published by Winter in the "Centralblatt für Gynecologie," 1923, No. 31. The various subdivisions correspond to Winter's paragraphs.

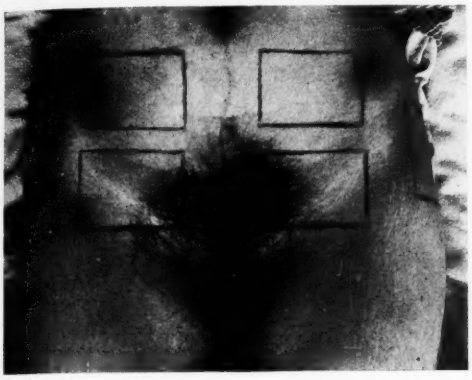

Fig. 5. (See text, page 502.)

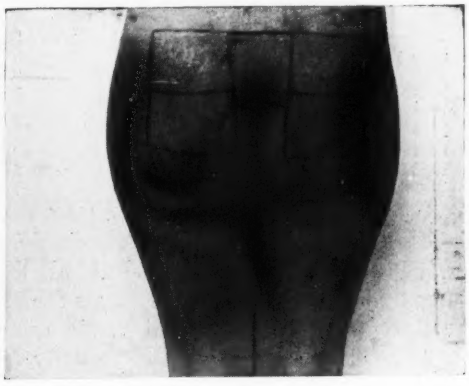

Fig. 6. (See text, page 502.)

The following group of statistics is divided into (*a*) carcinomata of the cervix uteri; (*b*) carcinomata of the corpus uteri.

1.—Total number of cases of cervix carcinoma (corpus carcinoma) which came for treatment to the Gynecological Clinic in Erlanger from 1915 to 1922. All cases which sought medical advice are included; also those which subsequently failed to come for treatment or had to be rejected as hopeless.

Year	Cervix Carcinoma	Corpus Carcinoma
1915	42	(8)
1916	66	(8)
1917	90	(4)
1918	109	(14)
1919	108	(11)
1920	104	(20)
1921	91	(18)
1922	98	(7)

2. — The carcinoma cases are divided into: (*a*) Operable cases, if the carcinoma is confined to the uterus and its immediate vicinity; (*b*) inoperable cases, if the carcinoma has involved the parametrium, the urinary apparatus, the glands and internal organs to such an extent that it cannot be removed by operative procedure.

In employing this classification I considered the following facts: It is generally known that the inflammatory infiltration of the parametria may be so intense that, on examination, the carcinoma is pronounced absolutely inoperable. Under the influence of X-rays and conservative treatment in the clinic, the infiltration, in most cases, recedes after the radiation of the primary tumor. But since such cases cannot be recognized with absolute certainty, on examination I counted doubtful cases as operable in this classification. It is possible that through such errors, the number of cures in the operable group is decreased, but since we are primarily interested in determining the value of X-ray therapy as

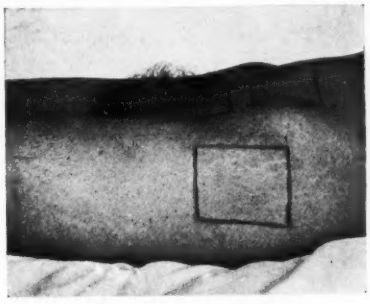

Fig. 7. (See text, page 502.)

critically as possible, such a mistake would only tend to increase the value of the statistics.

Year	Operable Cases		Inoperable Cases	
	Cerv. Carc.	Corp. Carc.	Cerv. Carc.	Corp. Carc.
1915	24	3	18	5
1916	14	3	52	5
1917	11	4	79	0
1918	18	7	91	7
1919	22	6	86	5
1920	12	9	92	11
1921	10	8	81	10
1922	12	2	86	5

3.—The result of the primary treatment is obtained by estimating all casualties which followed the treatment. Of all the cases treated from 1915 to 1923, we found, on most thorough investigation, six cases in which the irradiation could actually be considered as the possible direct or indirect cause of death. They were: Two cases of injury to the mucosa of the bladder with subsequent perforation and extravasation of urine. (These cases were taken care of outside the hospital after the termination of the X-ray treatment. Whether death would have ensued or not under scrupulous clinical after-care I do not know.) Two cases of phlegmon of the pelvis and peritonitis in which death occurred six to nine weeks after the X-ray treatment; in one case there was perforation into the intestines and subsequent peritonitis. I ascribe these casualties to X-ray therapy because they may have been caused by cross-firing and local over-dosage. In one case of a burn over the sacrum, death was due to sepsis following it.

One more case must be included here. The patient was returned to the clinic with high fever and in a run-down condition two years after the termination of the treatment. The bladder was entirely encrusted half a year after the radiation; a heretofore unobserved tendency toward stone formation in the bladder was noted. There were sharp and pointed urate stones, more than a hundred of which had been removed by means of a pair of dressing forceps by the general practitioner and the husband, during the past year and a half. Patient died of pyelonephritis and uremia shortly after admission to the clinic. At autopsy, the presence of carcinoma could not be demonstrated.

Thus, *the mortality percentage* following X-ray treatment of carcinoma of the uterus, as determined from the cases referred to, is less than 1 per cent. It is also to be noted that with the improved technic of dosage, the danger of death following X-ray treatment is limited only to very exceptional accidents.

4. — The "absolute cure, according to Winter." The following tabulation includes all cases which, five years after the treatment, showed no more evidence of carcinoma. The percentage is calculated from all cases coming to the clinic, no matter whether they were treated or not. No deductions were made in such a determination of the number of absolute cures.

THE NUMBER OF ABSOLUTE CURES AT THE GYNECOLOGICAL CLINIC IN ERLANGEN

Year	No. cases	Dec. 1	Cases living	Percentage of absolute cures
1915	42 (8)	1920	8[2] (2)	19[2] (25)
1916	66 (8)	1921	13 (2)	19.6 (25)
1917	90 (4)	1922	12 (2)	13.3 (50)
1918	109 (14)	1923	16 (4)	14.6 (28.5)
1919	108 (11)	1924	22 (4)	20.3 (36.6)
1920	104 (20)	1924	22 (9)	21.2 (45)

5. — Winter compares the number of absolute cures with that of relative cures. He applies the term "relative" to such cures as are obtained with a certain method of treatment (in our case, X-ray treatment) of the cases subjected to it. The period of observation after the termination of the treatment is five years.

NUMBER OF RELATIVE CURES

The following cases, both operable and inoperable, were treated with X-rays with

[2] Each first figure applies to the cervix carcinoma while the figure in the parentheses applies to the corpus carcinoma.

the following results, during the following period of time:

Year	No. cases	Dec. 1	No. cases living	Percentage of relative cures
1915	18 (5)	1920	1 (0)	55 (0)
1916	56 (6)	1921	10 (0)	18 (0)
1917	84 (4)	1922	12 (2)	14.2 (50)
1918	103 (14)	1923	16 (4)	15.5 (28.5)
1919	100(11)	1924	22 (4)	22 (36.3)
1920	97 (20)	1924	22 (9)	22.6 (45)

In tabulating these figures, the cardinal requirements of statistics according to Winter are fulfilled. The numbers of absolute and relative cures permit of a comparison of the results obtained at various clinics, provided that the selected methods of treatment and the clinical material treated are similar. In large statistical numbers minor differences are equalized.

In estimating the value of X-ray therapy and especially the usefulness of various methods of treatment, neither the number of absolute nor of relative cures furnishes an adequate basis. First of all, it is to be noted that the two values depend largely on the quality of the clinical material. From this it is apparent that with the same method of treatment from year to year, but with a change in the clinical material as to operability, the ultimate number of cures must change accordingly.

The statistics of many clinics show that, of the total number of cases of carcinoma admitted, the percentage of advanced cases has been much higher within the last few years than it was in pre-war times. In regard to this I made the following observations:

Year	Percentage of operable cases
1915	57
1916	21.2
1917	12.2
1918	16.5
1919	20.3
1920	10.5
1921	11
1922	12

These figures are not at all surprising, because tremendous psychic and physical hardships such as our nation has endured must manifest themselves in the morbidity of a population. During the war many women could not leave their homes to seek medical aid. No attention was paid to the slight initial hemorrhages seen in carcinoma. After the war, especially during the period of inflation, most of the patients sought medical advice only if some serious illness compelled them to do so. Even to-day, only few of the women who have slight hemorrhages caused by a small carcinoma apply for treatment. Thus, the poor quality of the cases admitted is an established fact. But this change has such a decided effect on Winter's number of absolute and relative cures that even considerable improvements in the treatment methods do not become apparent. This, I think, also explains the fact that there is very little variation in the number of absolute cures of most clinics, although the kind and quality of the treatment methods show such wide differences. In the following statistical groupings we shall attempt to adjust these discrepancies. The cases are divided into operable and inoperable ones according to the explanation previously given.

Some of the cases of carcinoma reported in the following X-ray statistics have also been treated with radium, but I do not hesitate to include them under the general heading of "Roentgen therapy"; the dose of radium was very small as compared with that of X-ray, so that it could have only a local effect. The criterion of radium, as well as of the X-ray tube, lies in the radiation. Although the radium rays have considerably shorter wave lengths, a collective grouping of all cases for statistics which emphasize the local effect of the treatment, would be erroneous; but since this group of statistics deals with the curative result, the small dose of radium as compared with the much larger X-ray dose is negligible as far as the ultimate result is concerned. Furthermore, the radiation technic has so much improved from 1916 to 1922, that there is certainly less difference between an exclusive X-ray therapy and the com-

bined treatment (X-ray and additional radium dose) than between the treatment methods of previous years. This, I think, should eliminate all doubt as to the justification of collective grouping of these cases.

The following is the statistical grouping of operable and inoperable cases treated with X-ray. The number of cures is computed in accordance with Winter's conception of a relative cure.

(1) NUMBER OF RELATIVE CURES OF OPERABLE CASES

Year	No. cases	Dec. 1	Cases living	Percentage of relative cures
1916	7 (1)	1921	4 (0)	57 (0)
1917	10 (4)	1922	4 (2)	40 (50)
1918	17 (7)	1923	9 (4)	52.9 (57)
1919	21 (6)	1924	12 (4)	57 (66.6)
1920	12 (9)	1924	9 (8)	75 (88.8)

(2) NUMBER OF RELATIVE CURES OF INOPERABLE CASES

Year	No. cases	Dec. 1	Cases living	Percentage of relative cures
1915	18 (5)	1920	1 (0)	5.5 (0)
1916	49 (5)	1921	6 (0)	12.2 (0)
1917	74 (0)	1922	8 (0)	10.5 (0)
1918	86 (7)	1923	7 (0)	8.1 (0)
1919	79 (5)	1924	10 (0)	12.6 (0)
1920	85 (2)	1924	13 (1)	15.3 (9)

Since X-ray therapy is not as yet a finished science, its methods of radiation technic as well as of dosimetry have changed from year to year; important improvements have been added. For this reason it seems important to me that in determining the usefulness of these methods one should not wait until the expiration of the five years' period of observation, but rather follow L. Seitz' suggestion of finding the "provisional number of relative cures" for a period of three years following the termination of the treatment. The majority of losses following the treatment of carcinoma occur within the first two years. Thus the three years' period of observation can be used statistically to check up the result of the procedure. In such a classification our cases are arranged as follows:

(3) PROVISIONAL NUMBER OF RELATIVE CURES OF OPERABLE CASES

Year	No. cases	Cases living 3 years later	Percentage of provisional cu
1916	7 (1)	5 (0)	71.4 (0)
1917	10 (4)	5 (3)	50 (75)
1918	17 (7)	10 (5)	58.8 (71.4)
1919	21 (6)	15 (4)	71.1 (66.6)
1920	12 (9)	10 (8)	83.3 (88.8)
1921	10 (8)	6 (5)	60 (62.5)

(4) PROVISIONAL NUMBER OF RELATIVE CURES OF INOPERABLE CASES

Year	No. cases	Cases living 3 years later	Percentag of pro- visional cu
1915	18 (5)	1 (0)	5.5 (0)
1916	49 (5)	7 (0)	14.2 (0)
1917	74 (0)	9 (0)	12.1 (0)
1918	86 (7)	9 (0)	10.4 (0)
1919	79 (5)	12 (0)	15.1 (0)
1920	85 (11)	14 (1)	16.4 (9)
1921	81 (10)	10 (2)	12.3 (20)

The total number of cases includes t absolutely hopeless cases. These cas render the statistics less favorable. Th were not excluded, so as to completely fu fill Winter's statistical requirements.

The difference between the number patients in the group of "absolute cure and that of "relative cures" is explain by the fact that a number of them fail to receive treatment.

The difference in the number of operab cases in Paragraph 2 and that of the st tistical groups 1 and 3 is accounted for the fact that during the period 1915-19 one or several operations had been pe formed. These cases were, of course, n added to those treated with X-ray, but we included in the number of absolute cure

In confining myself to the division of t cases into the two groups of operable a inoperable cases, I am fully aware of t fact that the strict requirements of stat tics, to include only identical cases in o group, could not be fulfilled. For th reason, other investigations have divid the cervix cases into four or five group such a system has been used in form publications in conjunction with L. Sei It is true that this entails a further subd vision of the various groups of figures a

increases the error of percentage calculation. Furthermore, the terms "operable" and "inoperable" can be defined much more precisely than that of "borderline cases" of another classification. In studying a group of statistics all factors which modify it must be considered.

The group of the inoperable cases is burdened with the totally hopeless cases. By these, I mean not only carcinoma cases in which there exists no hope for cure whatsoever, but cases in which even hope for any improvement is doubtful; in other words, general carcinomatosis, liver and lung metastases. To this group also belong the patients whose local findings give some hope but whose hemoglobin content is under 35 per cent and whose blood picture shows pathological forms in consequence of severe hemorrhages.

The following statistics were collected in order to ascertain if the X-ray treatment of inoperable carcinoma was successful in cases which had involved the adjacent structures, but in which no distant metastases had been found. They also show how long the inoperable and advanced cases lived after the termination of the treatment. The cases which, according to our conception, were absolutely hopeless, are excluded.

(5) STATISTICS OF INOPERABLE CASES AFTER THE EXCLUSION OF THE HOPELESS CASES

1915—Of 17 cases—Living:
Dec. 1, 1916— 6—35.2 per cent
Dec. 1, 1917— 2—11.7 per cent
Dec. 1, 1918— 1— 5.8 per cent
Dec. 1, 1919— 1— 5.8 per cent
Dec. 1, 1920— 1— 5.8 per cent

1916—Of 39 cases—Living:
Dec. 1, 1917—19—48.6 per cent
Dec. 1, 1918— 7—17.9 per cent
Dec. 1, 1919— 7—17.9 per cent
Dec. 1, 1920— 6—15.3 per cent
Dec. 1, 1921— 6—15.3 per cent

1917—Of 54 cases—Living:
Dec. 1, 1918—27—50 per cent
Dec. 1, 1919—14—25.9 per cent
Dec. 1, 1920— 9—16.6 per cent
Dec. 1, 1921— 8—14.8 per cent
Dec. 1, 1922— 8—14.8 per cent

1918—Of 70 cases—Living—
Dec. 1, 1919—36—51.1 per cent
Dec. 1, 1920—13—18.5 per cent
Dec. 1, 1921— 9—12.8 per cent
Dec. 1, 1922— 7—10 per cent
Dec. 1, 1923— 7—10 per cent

1919—Of 61 cases—Living:
Dec. 1, 1920—38—61.9 per cent
Dec. 1, 1921—22—35.9 per cent
Dec. 1, 1922—12—19.6 per cent
Dec. 1, 1923—12—19.6 per cent
Dec. 1, 1924—10—16.4 per cent

1920—Of 66 cases—Living:
Dec. 1, 1921—30—45.3 per cent
Dec. 1, 1922—21—41.7 per cent
Dec. 1, 1923—14—21.7 per cent
Dec. 1, 1924—13—19.6 per cent

The cases grouped under "operable carcinoma" are not qualitatively alike because they include the minutest carcinoma of the cervix in its initial state which can only be diagnosed microscopically, as well as the cauliflower tumor of the size of a hen's egg. Although they are both considered as being confined to the primary focus, they are just as different as to their degree of response to X-rays as they are to operation. In publishing statistics, the "selection" of cases is to be avoided. As my personal criterion for certain radiation methods, favorable cases which are as nearly alike as possible regarding their stage of development and extension are essential for comparison. I have collected many such statistical groupings in the course of time. They show the interesting result that the percentage of five-year cures, *e.g.*, the number of relative cures, as presented in it, does not exceed 85 per cent. In spite of excellent radiation methods employed in a favorable initial state and good general condition of the patient, one meets time and again inexplicable failures, which force one to the conclusion that other biological factors not yet known play a certain part in the cure of carcinoma by X-rays. I have already pointed out that general living conditions, adequate preliminary and after-care and nursing, are not to be underestimated. Statistical grouping with special reference to this shows that the prospects for cure are almost twice as good among patients living in favorable environ-

ments (sanatoriums, clinics and excellent economic conditions) as among those who, immediately after the treatment, resume work and household cares under poor domestic circumstances.

CONCLUSIONS

In conclusion, I find from all my experiences and observations of individual cases that the following factors, arranged in the order of their importance, are of decisive significance. The curative results of X-ray therapy depend upon:

1. Exact medical radiation technic, based upon and carried out with accurate dosage. The minor variations of sensitiveness of different carcinomata are negligible.

2. The kind, quality and degree of extension of the tumor to be treated (the earlier the diagnosis, the more favorable the result).

3. The topographical location of the carcinoma (proximity of organs very sensitive to X-ray).

4. The general living conditions of the patient, nursing care, feeding, proper medical attention after the treatment.

5. The "undisturbed retrogressive ability" of the carcinoma. The following conditions are complicating unfavorable factors: local infections; traumatic, chemical and physiological-chemical (internal secretory) irritations. Severe constitutional diseases and profound psychic disturbances diminish the resistance of the body against carcinoma.

6. The as yet unknown tendency of the body towards carcinoma. (Absolute failures in apparently favorable cases in the initial state, in spite of accurate radiation technic, occur in 15 to 20 per cent of the cases.)

RADIO-ACTIVE SUBSTANCES AND THEIR THERAPEUTIC USES AND APPLICATIONS

RADIOTHERAPY OF CANCER OF THE UTERINE CERVIX

By JOSEPH MUIR, M.D., New York

HISTOLOGIC EFFECTS OF RADIATION (CONTINUED) [1]

AS IT was in France that the element radium was first recognized, and in France also that its therapeutic properties originally became known, just so it is to that country especially that we look for the most minute and exacting observations upon the successive steps which have marked the advance of radium therapy. This is especially true of that branch of radium technic which has to do with the treatment of cancer of the cervix uteri, for in France, more than anywhere else, this particular therapy has reached its highest usefulness, and it is to the workers there that we who speak the English tongue, both here and on the other side of the Atlantic, are constantly turning for instruction, inspiration and leadership.

As far back as 1908 we find Dominici and Barcat, those pioneers in the therapeutic application of radium, discussing the histologic effects which the gamma rays produce upon carcinomatous tissues, and the relation which these bear to those previously noted when the gamma rays were applied to epitheliomatous neoplasms. In studying the histologic sequence of the regressive process, it was noted that the portions of the tissue which had been subjected to radium assumed a character essentially different from that displayed by tissues which had not been so exposed. This differentiation was especially noticeable in the alteration and variation in the direction of the connective tissue bundles. It was also pointed out by Degrais and Bellot that when the epitheliomatous cells are exposed to radium there takes place hypertrophy of the nucleus, degeneration of the protoplasm, and a certain amount of keratinization, which—after an interval of perhaps three weeks—advances until the entire epitheliomatous mass has been converted into keratinized débris. All the formed elements will have broken up and disintegrated, and there will be evident an infiltration with young fibroblasts and connective tissue cells, lymphocytes and polymorphonuclears, which appear to be carrying on a phagocytic function; while cicatrization is taking place at the expense of the cancerous growth's hyperplastic and regenerated stroma. Following the radium applications it will be seen that the cancer cells gradually shrink and lose their staining properties, but this atrophy does not correspond to the metamorphosis of these same definitely formed elements, but to their destruction, which is evidenced by keratinization or absorption. Thus the cancer cells seem to disappear either by progressive absorption of their protoplasm and nuclei, brought about by the leukocytic infiltration, or by a sort of granular degeneration. As Dominici and Barcat express it: "In its curative action, the gamma ray of radium at the same time combines a preventive action, for it restrains the evolution of the cancerous growth; first, in regard to the actually cancerous cells, which it metamorphoses, and, second, in regard to the epithelial cells, which, though normal in appearance still, are yet potentially cancerous, in which it inhibits the extension of the malignant transformation."

The years which followed the enunciation of these fundamental principles saw a rapid extension in the histologic knowledge of irradiation. In 1914, Morson, of the Middlesex Hospital, actuated by the investigations of Dominici, and assisted by the celebrated English gynecologist, Bon-

[1] See November issue, page 425.

ney, who placed material for examination at his disposal, was able to study the results of radiation upon extirpated carcinomata, both of the uterine cervix and their metastases in lymphatic glands. The tissue immediately in contact with an imbedded tube of radium was examined at intervals from forty-eight hours to two months after radiation, the period of exposure being usually from fifteen to twenty-four hours.

The dosage employed seems to have been 40 mgr. of radium bromide, but the lack of exact statement which characterizes so much of the earlier work on cancer of the cervix makes it difficult for us to visualize precisely the conditions under which these observations of Morson were made. He tells us that within fifteen hours of the commencement of radiation the malignant cells in the immediate vicinity of the tube of radium began to degenerate, the nuclei becoming irregular in shape, and in one or two places even broken up into fragments. Twenty-four hours later all that was visible was a structureless mass, embedded in which were a number of cells in various stages of degeneration. Outside the zone of greatest intensity of the rays, it was observable that the cells were altered, their normal arrangement being lost and the whole malignant mass being broken up into isolated cell groups. In some areas there was a definite line of demarcation between the cells which were degenerated and the other—relatively unaltered—malignant cells. Three days after radiation, the connective tissue cells were seen to have started to proliferate, and the malignant cells which still remained alive, showed evidences of vacuolation and greatly enlarged nuclei. In certain instances, as early as fourteen days after the tissues had been exposed to the action of the gamma rays, no evidence of cancer cells could be found. In many cases, however, the malignant cells proved highly resistant and even as long as two months after exposure, were still present, although somewhat changed in character. They had a peculiar vacuolated appearance, with swollen nuclei, while around them dense fibrous tissue could be seen. "The action of the radium on the connective tissue cells shows its similarity to the attempt of Nature to arrest the growth of cancer through overgrowth of fibrous tissue. . . . It is quite possible that the change produced in the cancer cell by the rays of radium is a chemical one, and it is only when in contact with certain constituents of the blood or lymph that these degenerative changes can take effect."

It was the experience of this investigator that the cells showed greater radiosensitivity in that type of squamous-cell carcinoma of the cervix uteri which gives rise to severe hemorrhage, than they do in other varieties of cervical carcinoma. With regard to columnar cell carcinoma, it was pointed out by both Dominici and Degrais that this type was peculiarly resistant to the effects of the gamma ray. In view of the fact that columnar cells are recognized as being the most delicate of epithelial structures, it is difficult to find an adequate explanation of this observation.

The overgrowth of the connective tissue elements which is in evidence even as early as the third day after exposure to radiation, has an important bearing on the later alterations in those cancer cells which were too far removed from the action of the gamma rays to undergo complete destruction. The suggestion is advanced that in the course of time those malignant cells which had managed to escape the lethal effects of the actual radiation, would be killed by the contraction of the newly formed connective tissue.

The observations upon metastasis in a lymphatic gland secondary to a squamous-cell carcinoma of the cervix which had been treated with radium, are of peculiar interest. Though it is well recognized that the cellularity of such a metastasis is fully as great as that of the primary growth, in the sections examined there were but a few "islands" of malignant cells, and these were surrounded by masses of newly

formed connective tissue. When this specimen was compared with others taken from metastases of cervical carcinoma which had never at any time been subjected to radiation, the differences were very noticeable. There was not the least resemblance in respect to the amount of fibrous tissue. Yet the metastatic growths were situated too far from the primary focus of malignancy to permit of these cells receiving any direct radiation, so there appears to be a possibility that the absorption of degenerating and degenerated cancer cells at the primary site, due to exposure to the gamma rays, leads to the formation of some substance which not only retards the growth of the malignant cell at a distance, but also stimulates the connective tissue cells to proliferate.

More recent work, especially that of Régaud and his associates, has applied the evidence collected by the earlier investigators to the practical problems of clinical employment. The speculations in regard to the possible effect of radiation upon metastasis have had perhaps a greater bearing upon the question of possible direct extension of the malignant process, and the ability of the gamma rays to check this extension in what the French term the *zone d'ensemencement latent*—the encircling potentially cancerous tissues, not yet actively involved in the malignant process—is to-day a question of far greater moment. Around the focus of radiation which is instituted by the introduction of a tube of radium into a cancer, a zone of sterilization is produced. The extent of this zone depends upon a number of factors, biologic, physical and geometric. We now realize that we can obtain a local cure in this zone, that is, a definite arrest of the cancerous process. If we can extend the effects of our therapy so that this zone of sterilization will encompass the zone of potential malignancy as well, we can then feel sure of attaining a true cure, that is, total eradication of the disease.

In an organism affected with cancer there will be established between that part of the organism which has remained healthy and the growing mass of the neoplasm a certain equilibrium of nutrition, by virtue of which the growth of the cancer is maintained at a constant rate. If this equilibrium has been upset by a partial suppression of the cancer—either by excision or destruction and absorption due to radioactivity—there will be a tendency to reestablishment; a compensating growth will immediately be stimulated, so that there will be a rapid proliferation of the neoplastic tissue. This newgrowth may arise either at the original site of the tumor, or in the preexisting zone of potential malignancy. This is in accordance with a large number of observations made upon experimental cancer. In the cancerous human subject, the compensatory growth is very rapid and extensive after insufficient radiation—more so than after incomplete surgical extirpation. This is because weak irradiation of the periphery of the neoplastic area has a distinctly excitant action, and also probably because the same substances which serve to assist the organism in regaining its normal balance, also serve the nutritive needs of that part of the neoplastic growth which has escaped destruction. It is not that improper radiotherapy favors the dissemination of malignant cells, as is a very current belief; it is rather that it favors this compensatory newgrowth.

The local effects in the neoplasm produced by radiotherapy consist, in the first place, in a suppression of the process of cell multiplication; in more efficient dosage it has a lethal effect upon a variable number of cancer cells; in its highest efficiency it extirpates, root and branch, the entire neoplastic growth. But if there exists, outside the actual growth, a living cancer-forming agent, which is distinct from the actual cancer cells, it is not reasonable to suppose that this, too, is destroyed. What for want of a more exact term we are accustomed to call the *predisposition to cancer*, will still be active. And if the present conceptions of this cancerous predisposition are correct, not only will it

remain, but its activity will actually be encouraged by the radio-activity which is applied to destroy the malignant tissues, as the vitality of the still unaffected surrounding area will be in a certain measure reduced by the effects of irradiation in their vicinity. Where normal and neoplastic tissues lie together, successive radiations in non-sterilizing dosage have an inverse effect upon normal elements and cancerous ones. An increasing intolerance is manifested by the normal tissues, which is explained by the fact that the normal tissues are not regenerated, or, if they are, the process is a very slow one; thus the dysbiotic effects of radiation have a chance to accumulate in the same normal tissue.

In the cancerous tissue, on the other hand, radiation tends to produce a constantly increasing immunity, both relative and absolute; relative, in respect to the increasing intolerance of the normal tissues; and absolute, in that the neoplasm seems actually to be inoculated against the deleterious effects of the rays. This phenomenon is explained in part by the multiplication of cells during the intervals of radiation, which takes place in those areas which are insufficiently radiated, or get no radiation at all. The dysbiotic effect of irradiation upon cancer is thus rapidly eliminated, and there is never opportunity for a cumulative effect such as takes place in normal tissue.

While these observations apply to all neoplastic growths under the action of the gamma rays, they are especially applicable in the treatment of cervical cancer. This type of neoplasm does not lend itself readily to investigation; only a very small area can be explored by palpation in the vagina or rectum. Despite the fact that the cure of this particular neoplastic lesion has been one of the most signal successes of radiotherapy, cervico-uterine cancer does not lend itself to experimentation, because we are unable to work with the same precision and accuracy which can be done elsewhere, and are never certain of the outcome of our efforts. Yet it is the opinion of these French observers, to whom in great measure our present success in the radium treatment of cervical cancer is due, that the principles readily applied in external lesions are exactly as applicable to the uterus, and that the only successful technic is that which takes into account the slowly accumulating histologic data which are now at our command.

LITERATURE

Aikens, W. H. B., and Simon, K. M. B.: The histological and clinical changes induced by radium in carcinoma and sarcoma. Dominion Med. Month., 43:97, 1914.

Dominici, Henri, and Barcat: Note sur le processus histologique de la regression des tumeurs malignes sous l'influence du rayonnement (gamma) du radium. Soc. de Biol., 64:1052, 1908.

Hartmann, Henri: Curietherapie dans le cancer du col et dans le cancer de l'uterus. Gynec. et Obst., 4: No. 4, p. 301, 1921.

Morson, A. C.: The changes which occur in malignant tumors on exposure to the gamma rays of radium. Arch. Middlesex Hosp., 33:110, December, 1914.

Regaud, C., *et al.:* Sur la technique de la Curietherapie dans le cancer du col de l'uterus. Bull. de l'Assoc. franc. pour l'étude du cancer, 9:224, 1920.

THE NORMAL AND PATHOLOGICAL APPENDIX

A Clinical Roentgenological Study [1]

By ROBERT A. ARENS, M.D., and ARTHUR R. BLOOM, M.D., Roentgenologist and Fellow in Radiology, respectively, of Michael Reese Hospital, Chicago

INTRODUCTION

CHRONIC appendicitis, from the roentgenological and symptomatological viewpoints, has been frequently discussed during the last decade. Observations on the normal appendix have scarcely been mentioned except by Jaisson (1), who arrived at some very definite conclusions on his findings in one apparently normal case; and Czepa (2), who examined 144 normal cases. Our purpose in presenting this article is to submit our findings in normal individuals and a review of those cases in which a roentgenological diagnosis of chronic appendicitis was made.

The earliest record of the radiological demonstration of the appendix was that of Béclère (3), in 1906. Later, Liertz, Reid, and Grigorieff (15) reported similar observations. In succeeding years the visualization of the appendix by fluoroscopy and radiography became more and more frequent. In 1913, George and Gerber (4) reported that the appendix could be seen in 70 per cent of their cases.

Spriggs (5), Pfahler (6), Pratt (7), Pancoast (8), Ellis (9) and numerous other authors all call attention to the fact that retention of barium, localized tenderness, kinks, and adhesions are the X-ray findings on which a diagnosis of chronic appendicitis should be made.

METHOD OF STUDY

For purposes of study we divided our cases into three groups. Group 1 consisted of 48 cases in which a roentgen diagnosis of chronic appendicitis was made and the patients operated on. Group 2 comprised 35 cases in which a roentgen diagnosis of chronic appendicitis was made but no operation followed. Group 3 contained 102 cases who gave no history of any intestinal symptoms and were examined in order that the roentgenological findings of the appendix in the normal individual might be ascertained.

The technic employed in Groups 1 and 2 consisted of our routine method of examining gastro-intestinal cases and included previous purging with castor oil. In Group 3 we merely gave the patient a barium meal and examined him 24, 48, 72 and, in a few cases, 96 hours afterwards. Contrary to the opinion of Spriggs, the appendix was visualized as frequently in Group 3 as in those cases in which we made the routine examination, having purged with castor oil beforehand.

SYMPTOMS OF CHRONIC APPENDICITIS

The symptoms of chronic appendicitis and their frequency are based on our results, after carefully reviewing the histories of those cases in Groups 1 and 2, as tabulated in Table I.

TABLE I

SYMPTOMS

	Group 1		Group 2		Combined Groups 1 and 2	
	No.	%	No.	%	No.	%
Total cases	48		35		83	
Pain in abdomen	46	95.83	27	77.14	73	88
Nausea	16	33.33	8	22.85	24	28.91
Belching	10	20.83	7	20.00	17	20.48
Constipation	9	18.75	12	34.28	21	25.30
Vomiting	9	18.75	10	28.57	19	22.89
Heartburn	8	16.66	4	11.42	13	15.66
Headache	6	12.50	7	20.00	13	15.66
Loss of appetite	4	8.33	4	11.42	8	9.64
Loss of weight	4	8.33	3	8.57	7	8.43
Distress after meals	4	8.33	4	11.42	8	9.64
Dizziness	4	8.33	3	8.57	7	8.43
Fatigue	4	8.33	7	20.00	11	13.25
Diarrhea	3	6.25	4	11.42	7	8.43
History of previous attack	12	25.00	6	17.14	18	21.68
Tenderness	42	86.66	23	65.71	65	78.31
Average white blood corpuscles	9,940		10,300		10,120	

[1] From the Radiological Laboratory and the Otto Baer Fund for Clinical Research of the Michael Reese Hospital, Chicago. Paper read before the Radiological Society of North America, at Atlantic City, May, 1925.

Pain in the abdomen was present in 96 per cent in Group 1 and 77 per cent in Group 2, or 88 per cent in the combined groups. These figures compare favorably with those of Mixter (10). This pain varies in location, character, time and type. It is usually located in the lower right quadrant, but frequently occurs in the epigastrium. It may be dull, aching or sharp in character. It may be continuous or recurrent. Frequently it bears some relation to meals.

Nausea is the next most frequent symptom. It was present in 33 per cent of Group 1 and 23 per cent of Group 2—29 per cent of the combined groups. It may or may not be accompanied by *vomiting*, which occurred in 23 per cent of the combined cases.

Belching was present in 21 per cent of the cases, while such other symptoms of gastro-intestinal disturbance as heartburn, headache, loss of appetite, distress after meals, dizziness and fatigue were found in from 9 to 16 per cent of the cases.

Constipation was complained of in 25 per cent; diarrhea in only 9 per cent. We did not note any substernal fullness, as described by Cushway (11).

History of previous attack was obtained in 22 per cent. These figures are in all probability rather low, many of the patients not recalling a previous attack, which may have been so mild that they did not seek medical advice, or the attack having come too early in the patient's life to be remembered.

Physical examination, as a rule, revealed only localized tenderness, found most frequently in the lower right quadrant, but, at times, much higher, being located as high up as the gall-bladder area and epigastrium. This tenderness was present in 78 per cent of the cases. Mixter reports it in 59 per cent. There was practically no other finding.

The leukocyte count varied from 6,000 to 17,000. The mean count was 9,500.

Fig. 1. Case A61136. Appendix lying to outer margin of hepatic flexure and under liver. Definitely tender. Seen 48 hours after ingestion of meal. Findings confirmed by operation.

CASE REPORTS

Case 1, A61136. Mrs. F., aged 59, complained of pain in abdomen, belching and jaundice. Belching had been present for several years. Pain in epigastrium came on half an hour after meals and radiated to back. During the last few days, patient had become jaundiced. No previous similar attack. *Past history:* "Appendectomy twenty years ago." *Physical examination:* Conjunctiva icteric. Heart and lungs negative, abdomen slightly distended, with some tenderness in right upper quadrant. *Laboratory findings:* W.B.C. 9,000; R.B.C. 4,900,000. Urine showed presence of bile. *X-ray examination:* Stomach normal, orthotonic; duodenum showed restricted lateral mobility. *Appendix* visible, lying to outer margin of hepatic flexure and under liver (Fig. 1); definitely tender; still filled at 48 hours. Films revealed a large gall-bladder shadow. *Roentgen diagnosis:* Pathological gall bladder and chronic appendicitis. *Operation:* Gall bladder distended, no stones. Head of pancreas firm and infiltrated. Appendix

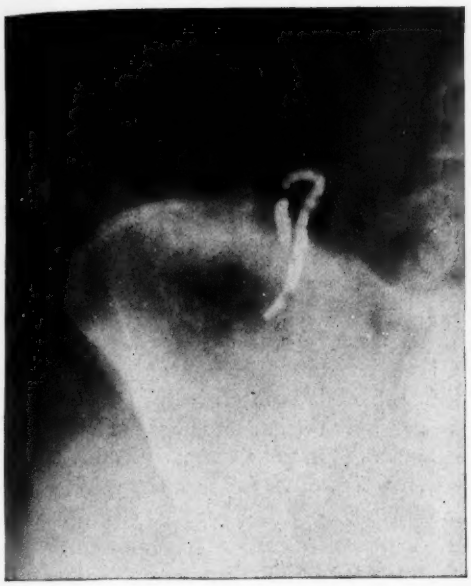

Fig. 2. Case A61014. Appendix seen at 24, 48 and 72 hours. Kinked, segmented and exquisitely tender. Cecum entirely empty at 48 hours. Findings confirmed by operation.

Fig. 3. Case A59035. Appendix filled by barium enema. Still filled and tender 24 hours later. Appendix under liver. Clinically, case resembled one of pathological gall bladder. Findings confirmed by operation.

found under liver with definite evidences of old inflammatory changes. As the important lesion was considered a carcinoma of the head of the pancreas, the abdomen was closed without removing any tissue.

Case 2, A61014. Mrs. S. L., age 22, complained of pain in right lower abdomen, epigastrium and right hypochondrium as well as of leukorrhea. Occasional mild pains in the lower right quadrant had been experienced up to about two weeks previous to entrance to hospital. After this time, the pain became quite severe. Pain was sharp and radiated to back and right costal margin. *Past history:* Acute gonorrheal infection and pelvic peritonitis after marriage. Cesarean section. *Physical examination:* Tenderness over right kidney region and lower right quadrant. *Laboratory findings:* W.B.C. 7,600; urine negative. *X-ray examination:* Appendix was visualized, segmented, and unusually long and exquisitely tender under palpation. It was still visible at 72 hours (Fig. 2). Colon emptied at 24 hours. *Operation:* Appendectomy. Appendix long and injected and filled with barium. *Pathologist's report:* Acute catarrhal appendicitis.

Case 3, A59035. Miss H. C., age 29, entered hospital complaining of nervousness, pain in lower abdomen, tiredness, headache and temperature. Pain in right iliac region and hypochondrium. Appetite poor. *Past history:* Negative. *Physical examination:* Thyroid enlarged. Tenderness on deep pressure in gall-bladder and both iliac regions. *Laboratory findings:* R.B.C. 4,820,000; W.B.C. 11,700; polymorphonuclears 68 per cent; small lymphocytes 22 per cent. Urine and stools negative. *X-ray examination, opaque enema:* Ileocecal valve incompetent. Retroperistalsis forcing barium into ileum. Hepatic flexure, cecum, and ascending

colon occupy an atypical position, the cecum being up in the gall-bladder area and the appendix taking a course downward and outward (Fig. 3). Tenderness over appendix. Patient was operated on at another hospital. The appendix was found to be under the liver; it was long, injected and covered with adhesions. Another member of the family was operated on some years ago and the appendix found in the same position.

PATHOLOGICAL FINDINGS

The pathological findings were based on the description given by the surgeon at operation and the report from the pathologist. In six cases, or 12.5 per cent, there was no demonstrable pathology (Table II).

TABLE II

PATHOLOGICAL FINDINGS

Group 1

	Number	Percentage
Adhesions	18	37.50
Congestion	12	25.00
Kinked	12	25.00
Subacute changes	12	25.00
Enlarged	10	20.82
Mucosa edematous	9	18.75
Fecaliths	5	10.41
Retrocecal	5	10.41
Tip obliterated	3	6.25
Pathological changes	42	87.50
No pathological changes	6	12.50

Adhesions were noted in 18 cases, or 37.5 per cent; congestion in 25 per cent, and 25 per cent of the appendices were found kinked. Twelve cases showed subacute changes histologically. In ten cases the organ was definitely enlarged or swollen, while in nine instances the mucosa was found edematous. Fecaliths were found in five cases. An equal number were found to be retrocecal.

In a number of instances in which the appendix was demonstrated fluoroscopically and radiographically, the pathologist reported an obliterative process. This does not mean a faulty observation on our part or on that of the pathologist, but simply that the distal end was sectioned, in which obliterative changes had set in. The fact that no pathological changes could be found in some of the appendices does not exonerate that organ, as symptoms may be caused by abnormal physiological reactions.

X-RAY FINDINGS

Visibility. — The appendix was visualized in 84 per cent of the cases of Group 1, and 86 per cent in Group 2. The barium was retained in the majority of instances for 48 hours or more.

George believes that an appendix which does not fill is pathological. However, we do not agree with him, as the appendix failed to fill in only a few cases of chronic appendicitis, *i.e.*, 7 per cent of Group 1 and 14 per cent of Group 2. In all these cases the cecum and caput coli were definitely and exquisitely tender.

Skinner (12) states that an appendix which fills and remains so for some length of time is either diseased or potentially so. We do not consider the mere filling of an appendix pathological, but if it remains so longer than a reasonable time (about 24 hours after the cecum has emptied) (Fig. 2), then it has a marked significance.

In only a few cases were we able to fill the appendix by barium enema. The reason may be that the increased pressure resulting from a clysma produces a more perfect closure of the valve of Gerlach than when the barium enters by the slower method, *i.e.*, by ingestion. Again, it may be that the appendix is filled with fecal contents at the time and has had no opportunity of emptying itself, as when the barium is taken by mouth and examined 24 to 48 hours later. However, we have been led to regard an appendix which fills readily after a barium enema as pathological.

Tenderness localized directly over the visible appendix was noted in 93 per cent of Group 1 and 83 per cent of Group 2. This was so definite that when the appendix was moved, the point of tenderness moved with it. In view of the latter, it is rather

surprising that tenderness is so often found at McBurney's point, as the appendix may not be in that region at that particular time. Laroche, Brodin and Ronneaux (13), Pfahler and others have called particular attention to this fact. To elicit this tenderness it is necessary to impinge the appendix, as otherwise it may roll or slip from under the palpating finger. This is done by having the patient take a deep breath, blocking the downward and upward passage with the fingers of one hand, and then bringing the palpating finger of the other hand on to the appendix which is secured between the fingers of both hands and the iliac fossa. It is necessary to palpate from the right side of the patient, as it is frequently impossible to secure the appendix while manipulating from the left.

Mobility. — Many authors have called attention to limited mobility. In our series, this was not a common occurrence. Limited mobility, of course, means adhesions. However, the fact that the appendix is freely mobile does not rule out adhesions, as this organ may be attached to the ileum, omentum, and cecum, which at that time may be mobile. These organs, when empty, are, of course, invisible.

Kinks when found are significant. We have paid no attention to segmentation. Many authors have called attention to what they have termed secondary findings such as pylorospasm, ileal stasis, and incompetency of the ileo-cecal valve. We agree with Carman (14) that the direct findings are usually so definite that we need not put much weight on indirect signs.

There is another significant finding which we have noticed in quite a number of cases, *i.e.*, evidences of colitis, such as spasticity, or tubulization and tenderness of the descending colon and sigmoid. Many internists have called attention to the fact that some cases of obstinate colitis which will not react to medicinal therapy are sometimes cured by appendectomy. John B. Deaver in his early teaching called attention to the significance of mucus in the stool in relation to chronic appendicitis.

DIFFERENTIAL DIAGNOSIS

From the symptoms it can be seen that peptic ulcer, latent cholecystolithiasis, chronic cholecystitis, stone in the right ureter and chronic pelvic conditions must be excluded. Chronic cholecystitis, gallstones, and peptic ulcer can invariably be ruled out by a complete gastro-intestinal examination. Frequently we have had cases in which a clinical diagnosis of gallbladder disease had been made and in which there was definite tenderness in the right hypochondrium. On X-ray examination the appendix was found in that region (Figs. 1 and 3) or there was a long appendix pointing toward, or the tip was adherent to, the gall bladder. We have also had quite a number of cases of co-existing duodenal ulcer, pathological gall bladder and chronic appendicitis.

Stone in the right ureter and other kidney conditions can be excluded by straight kidney films, shadowgraph catheters and pyelogram; pelvic conditions, by exclusion and pneumoperitoneum.

EXAMINATION OF NORMAL CASES

This series consisted of 102 cases, divided into three classes. Class A contained a group of 22 children up to 14 years of age. Class B, 56 cases from 15 to 29 years, inclusive, and Class C, 24 cases from 30 years upward. This was to determine

TABLE III

X-RAY FINDINGS

	Group 1	Group 2	Group 3		
			A	B	C
Total	48	35	22	56	24
Visible	40	30	5	21	3
Last Seen—					
24 hrs.	7	11	2	8	2
48 hrs.	27	13	3	6	1
72 hrs.	6	6	0	7	0
Mobility—					
Free	37	28	3	14	3
Moderate	0	0	0	6	0
Limited	3	7	2	1	0
Tenderness	37	25	1	5	1
Not visualized	8	5	17	35	21
Cecum tender	8	5	0	0	0

the relation of the age of the individual to the roentgenological findings.

Each subject was questioned closely as to gastro-intestinal symptoms such as pain, vague sensations in the region of the abdomen, nausea, vomiting, or distress, as well as to history of previous attack of abdominal pain. Each was given a barium meal and examined at 24, 48, 72, and in a few cases 96 hours afterwards. At first they were also examined at 6 hours, but it was found that as a rule it was difficult to ascertain at that time the presence or absence of a visible appendix because the terminal ileum was usually filled and obscured the view. The findings were all recorded in this group, even though some cases showed evidences which corresponded with our idea of what constituted a pathologic appendix.

Visibility. — The appendix was visualized in 5 cases of Class A (18 per cent); in 21 cases of Class B (32.5 per cent), and in only 3 cases of Class C (12.5 per cent). These findings tend to substantiate Skinner's observation that the normal appendix is not visualized after thirty years of age. However, it does not account for the relatively few cases in Class A. Our percentage, 27.5 per cent (26 out of 102) is much higher than that of Czepa, who visualized the appendix in only 26 cases out of 144 examined, or 18 per cent.

Mobility. — In Class A, 3 were freely mobile and 2 were limited. In Class B, 14 were freely mobile and one case definitely immobile. In Class C all three were freely mobile.

Tenderness. — One case was tender in Class A, five in Class B and one in Class C.

Not Visualized.—In 82 per cent of Class A, in 62.5 per cent of Class B, and in 87.5 per cent of Class C, the appendix was not visualized. In not one of these cases—a total of 73—was the cecum tender. This is a very important sign in diagnosing chronic appendicitis in those cases in which the appendix is not seen. As noted above in Groups 1 and 2, every case in which a diagnosis of chronic appendicitis was made and the appendix not seen, the cecum was definitely and exquisitely tender. However, in these instances pathological conditions of the cecum and ileum such as carcinoma, tuberculosis, colitis and other disease must be ruled out.

These cases do not take into account a certain number in whom the appendix is potentially diseased, or abnormal, but symptomless, as occurs in a certain number of cases of cholecystitis and cholelithiasis, or those who had forgotten a history of a previous attack or for some reason denied the fact, as illustrated in the following:

Case 4. E. B., female, aged 18, was examined, together with a group of normal individuals. At the time of examination she denied any previous attack or any abdominal or gastro-intestinal symptoms. Fluoroscopic examination revealed a filled appendix at 48 and 72 hours, which was curled and could not be straightened. It was definitely tender. Point of tenderness moved with appendix.

Two months later, patient complained of an attack of pain in the lower right quadrant, and nausea. W.B.C. 7,000. At this time she admitted previous attacks which she "had forgotten about" when questioned at first. A clinical diagnosis of recurrent attacks of chronic appendicitis was made at this time.

CONCLUSIONS

1. The normal appendix is usually not visualized by X-ray, but, if so, empties within a reasonable time after the cecum. It is freely mobile and there is no tenderness.

2. X-ray findings of chronic appendicitis are usually those of a visualized appendix which is tender on direct palpation. There may or may not be limited mobility, non-drainage or abnormal location. In those cases in which the appendix is not visualized the cecum is definitely and exquisitely tender.

3. Symptoms of chronic appendicitis consist of abdominal pain, nausea, vomit-

ing, belching, gastric distress in relation to meals and, in a large percentage of cases, a history of previous attack may be obtained.

4. Pathological findings are usually those of adhesions, congestion, edema of the mucosa and fecaliths.

BIBLIOGRAPHY

1. Jaisson, C.: Etude radiologique de l'appendicite dans l'appendicite chronique. Jour. de radiol. et d'electrol., Paris, 1921, V, 256.
2. Czepa, A.: Zur Darstellung der Appendix in Röntgenbilde. Wien. klin. Wchnschr., 1924, XXXVII, 673.
3. Beclere, H.: Bull. de Soc. de Radiol., 1909, I, 192.
4. George, A. W., and Gerber, Isaac: Value of Roentgen Method in Study of Chronic Appendicitis and Inflammatory Conditions, Both Congenital and Acquired, about Cecum and Terminal Ileum. Surg., Gynec. and Obst., 1913, XVII, 418.
5. Spriggs, E. I.: Examination of Vermiform Appendix by X-rays. Lancet, Jan. 18, 1919, I, 91.
6. Pfahler, G. E.: Roentgen Rays in Diagnosis of Appendicitis. Am. Jour. Roentgenol., Feb., 1919, VI, 78.
7. Pratt, H. H.: Roentgen Diagnosis of Chronic Appendicitis. Miss. Val. Med. Jour., Louisville, 1920, p. 141.
8. Pancoast, H. K.: Roentgenologic Aspect of Chronic Appendicitis. Arch. Surg., 1923, VI, 85.
9. Ellis, L. E.: Intestinal Radiography for Chronic Appendicitis. Med. Jour. So. Africa, April, 1921, XVI, 163.
10. Mixter, C. G.: Chronic Appendicitis in Childhood. Jour. Am. Med. Assn., Sept. 27, 1924, LXXXIII.
11. Cushway, B. C., and Maier, R. J.: Symptomatology and Radiological Findings in Chronic Appendicitis. Radiology, Dec., 1923, I, 212.
12. Skinner, E. H.: Roentgenology of Appendiceal Obliteration. Jour. Am. Med. Assn., Dec. 11, 1920, LXXV, 1614.
13. Laroche, G., Brodin, P., and Ronneaux, G.: Chronic Appendicitis—Importance of X-ray Examination. Presse med., April, 1922, XXX, 297.
14. Carman, R. G., and Miller, Albert: Roentgen Diagnosis of Diseases of Alimentary Canal. Philadelphia, 1917.
15. Liertz, R., Reid, and Grigorieff: Quoted by Spriggs (5).

THE FIRST THREE ESSENTIALS IN THE DEVELOPMENT OF THE X-RAY ART

By E. C. JERMAN, Chicago

THE three essentials, each of which is of equal importance with the others, in the development of the X-ray art from a diagnostic standpoint, are, in the order of their proper sequence, Equipment, Technic and Interpretation.

1. *Equipment.*—The technician or radiologist must first be provided with equipment before he can proceed to develop the knowledge and skill necessary for his advancement. The selection of equipment has much to do with the success or failure of his efforts; indeed, his progress and success may be made very difficult or even impossible or they may be made comparatively easy, according to the equipment used.

The equipment must have sufficient capacity to do the work undertaken, otherwise, the energy, time and material used are but wasted. The machine must be capable of delivering the electrical energy required to do the work, and the tube must be of sufficient capacity to carry the necessary electrical energy and to deliver the energy thereby created. The attempt to successfully radiograph the chest of a two-hundred-pound individual, at a four-foot distance, in one-tenth of a second, with a portable or bedside unit, could only result in failure. The portable or bedside units lack the capacity for such work. An attempt to successfully radiograph the chest of the same individual, at the same distance, in one-tenth of a second, with a 5–10 radiator tube, would probably result in wrecking the tube, as this tube lacks the capacity for such work. If you desire to climb a steep grade with an automobile, the engine must be large enough to develop sufficient power and the driving mechanism must have sufficient capacity; otherwise, you are wasting your energy, time and gasoline, and, furthermore, may damage the car.

It is very important that the equipment be provided with the proper control, as this is of almost equal importance with capacity. In the manipulation of equipment there are four factors that bring about the end-result—the radiograph. They are:

(*a*) distance
(*b*) time
(*c*) milliamperage
(*d*) voltage or penetration

There is little or no difficulty in controlling the *distance factor*, as this remains constant when once fixed, and may be readily fixed at any desired point.

The *time factor* is more important, especially when a second or fractional seconds are used. With exposure from two or three seconds and upward, there should be but a small percentage of error with the careful use of a watch or clock. Fractional second exposures necessitate the use of a reasonably accurate time switch in order that such exposures may be duplicated with the minimum percentage of error. The shorter the time of exposure the greater the necessity for an accurate time switch.

The *milliampere factor* requires the use of a finely graduated milliamperemeter. With perfect line conditions the milliampere factor should remain fairly constant when once fixed. As only occasionally perfect line conditions are available, a stabilizer is the best known method for holding this factor constant when such line variations occur.

The proper control of the *voltage or penetration factor* requires the use of a finely and evenly graduated auto-transformer control. Where variations of the line voltage exist the use of a pre-reading voltmeter across the auto-transformer is a very decided help in keeping this factor constant. If it is desirable to control the

end-result — the radiograph, the factors which bring about that result must be brought under control of the operator. A variation of 25, 50 or 100 per cent in either the time, milliampere or voltage factor must result in just that percentage of variation of the radiographic density of the resulting film. A total variation, up or down, of all three factors combined, of 25, 50 or 100 per cent must also result in just that percentage of variation of the radiographic density of the resulting film.

Your automobile may develop an abundance of power and the driving mechanism have adequate capacity, but if the steering gear is out of order or any part of the control mechanism fails, you will endanger your own life and the lives of those who accompany you or who may happen to cross your way. Your X-ray equipment may have an abundance of capacity, but with a lack of proper control the quality of your work must pay the penalty and, furthermore, you may endanger yourself, your assistants, or your patients. You may be equipped with the finest, the most expensive, the most complete equipment the world has produced, with ideal line conditions and a perfect installation, and yet it would all be of no value without some person qualified to properly manipulate it in such a way that worth-while results might be obtained. You may purchase the best automobile in the world, but the car is useless until you, or some one for you, masters its proper manipulation. The better the driver, the more value will be obtained with the use of this car. Just so, there are many adequate X-ray equipments in use to-day rendering but a small part of the service of which they are capable, simply because their operators do not possess the knowledge and skill necessary to bring about the best possible results.

2. *Technic.* — Good technic requires considerable skill, and skill is something that cannot be purchased or given away, cannot be transmitted or communicated from one to another. It can be acquired only by practice and experience. There are many factors, aside from those above mentioned—time, distance, milliamperage and voltage—that contribute to the end-result—the radiograph. Some of the more important of these factors are the speed, lag, grain, contact and cleanliness of the screens, speed and quality of the films, volume and quality of the darkroom illumination, quantity and quality of the chemicals used in the darkroom, temperature of the solutions, age of solutions, time of development, rinsing, washing and fixing, positioning of the patient, alignment of tube, patient and film, distance of part exposed from film, distance of tube from film, size of tube focal spot, the condition of the patient in reference to size, pathological conditions and immobilization.

Technical skill will be more rapidly acquired by arranging all the factors involved into groups, such as the operating room factors, darkroom factors, equipment factors, screen factors, film factors and patient factors. The operating room factors, the darkroom factors and the equipment factors may be subdivided into smaller and closely related groups. Following the grouping of the factors, a careful experimental study of each single factor of a group or sub-group should be made until the action of that single factor is thoroughly understood. A systematic method of procedure will enable one to acquire the necessary skill with the least expenditure of time, material and work.

The finest and most expensive equipment, with ideal line conditions and a perfect installation, combined with the efforts of the best technician available, will still result in naught unless some one qualifies to properly interpret the films. The highest quality of films that can be produced are of no value until some qualified person obtains from these films the information which they make available. This brings about the necessity for a trained professional man.

3. *Interpretation.* — Interpretation requires not only a knowledge of normal

and pathological anatomy, but also a knowledge of its application from an X-ray standpoint. Knowledge and skill are required equally as well from an interpretative standpoint as from a technical standpoint. The higher the quality of the radiograph, the more information should be available. Even the professional man may err in the interpretation of a radiograph of high quality unless he shall have acquired in advance the proper knowledge and skill.

Frequently a thorough knowledge of the history and clinical findings in the case is necessary to properly interpret the radiograph. Variations from the normal, not pathological, must also be taken into consideration. The properly qualified radiologist will fix the highest standard of quality that may be attainable in his radiograph; then it is the duty of the technician to put that standard into routine practice. The equipment should function properly in every way, in order that the technician may not be prevented from carrying out his part of the work. The degree of success attained by an X-ray laboratory may be reduced or even entirely destroyed by any one of various handicaps that may be permitted to intrude, in the way of inadequate equipment, faulty technical procedure, or misinterpretation. Only by careful consideration of the details of all three essentials can success reach the maximum.

The modern X-ray laboratory represents a considerable investment, including such items as the cost of equipment, of electrical energy, of the chemicals and films used, the rental value of the floor space occupied, the income to which a properly trained radiologist is entitled, and the salary of one or more properly trained technicians. Oftentimes several small and easily removed handicaps are permitted to materially reduce the income which should be available as a result of this total investment. With careful and proper attention to all the details, a modern X-ray laboratory should prove an entire success from a financial standpoint, as well as from the standpoint of real service rendered to the patient.

CASE REPORTS

MULTIPLE DIVERTICULA, WITH HEMORRHAGE, IN THE WALL OF THE STOMACH: REPORT OF CASE [1]

By CHARLES G. SUTHERLAND, M.B. (Tor.),
Section on Roentgenology, Mayo Clinic,
ROCHESTER, MINNESOTA

A man, aged fifty-one, came to the clinic complaining of hemorrhage into the bowel. About one year before, he had noted tarry stools, and two months later had consulted his home physician because of increasing

Fig. 1. Filling defect in pyloric end of stomach. Roentgenoscopically the margins were smooth and the contour of the stomach was intact throughout, suggesting a benign lesion.

weakness and anemia. A diagnosis of gastric ulcer was made at that time. The condition apparently cleared up with treatment until three weeks before the patient came to the clinic, when the stools became tarry again.

General examination elicited no definite

Fig. 2. Gross specimen from the peritoneal side showing the diverticulum protruding from the wall of the stomach.

history of stomach disorder, but melena and anemia were present. Roentgenoscopic examination revealed a filling defect with smooth margin in the pyloric end of the stomach; the contour of the stomach surrounding the filling defect was normal throughout, and the lesion was therefore diagnosed as a probable benign tumor (Fig. 1).

At operation, a tumor was found in the posterior wall, close to the greater curvature and projecting down under the mesocolon (Figs. 2 and 3). Macroscopically the tumor suggested a sarcoma, but there was no glandular involvement. On patho-

[1] Received for publication October 28, 1925.

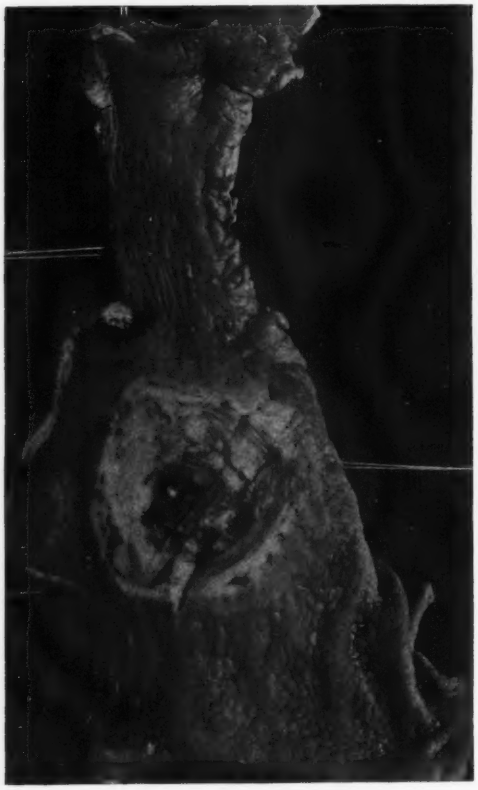

Fig. 3. Gross specimen from the mucosal side, looking into the crater of the diverticulum.

logic examination it proved to be two diverticula of the wall of the stomach, with hemorrhage into the sacs. A section of the stomach was excised from a point 7.5 cm. above the pylorus to above the incisura angularis, and end-to-end anastomosis performed. The patient had an uneventful convalescence and was dismissed to return home three weeks after the operation.

FIBROID UTERUS WITH BLADDER COMPLICATIONS

By L. J. CARTER, M.D., Brandon, Man.

Mrs. J., age 43. *Complaints:* (1) Uterine hemorrhage. Menstrual period every three weeks and lasting two weeks, and accompanied by severe pain. (2) Soreness and tenseness after urination. Cannot retain urine.

Fig. 1. (Above) Four ounces and (below) eight ounces of 15 per cent sodium bromide solution in bladder.

History: Right ovary removed and fixation of uterus to anterior abdominal wall nine years before present examination.

Physical examination: Uterus much enlarged, fibroid in character, acutely anteflexed, and fixed to anterior abdominal wall, just above symphysis pubis.

Barium enema: Entire sigmoid extremely spastic and tender.

Cystoscopy: Bladder is drawn to right. Right side of bladder fills first. Later, all bladder fills. Base of bladder is pushed forward and central area bulges downward, indicating pressure by an external tumor from above and in front. Bladder mucosa normal.

Cystogram: Bladder is depressed in central area by some external tumor pressing from above.

Diagnosis: (1) Fibroid uterus with hemorrhage. (2) Bladder displaced by uterus, fixed too low at operation, and since become site of fibroid enlargement.

Treatment: (1) Subtotal hysterectomy advised, but refused. (2) Deep X-ray therapy to control hemorrhage and reduce fibroid.

Note: It will be interesting to note whether the reduction in size of uterus following X-ray treatment will give relief from bladder symptoms. This case will be followed up.

NECROPSY OF A ROENTGENOLOGIST

By EUGENE C. PIETTE, M.D., West Suburban Hospital, OAK PARK, ILLINOIS

The last will of Dr. S. P. Grigorjev, one of the best of the Russian roentgenologists, directed that his body be examined. Having devoted himself to the study of X-rays since the beginning of roentgenology, he had lost his fingers one after another from a painful roentgendermatitis. While in possession of his full mental powers he died unexpectedly at the age of forty-six from typhoid fever. The course of this typhoid was unusual, in that there were three successive relapses, a condition corresponding, however, to the findings on postmortem examination.

The interesting features of this rare case of X-ray influence of twenty years' duration are as follows: The dorsal surfaces of the hands present a classical picture of roentgendermatitis. (Some time before his death, while travelling, Dr. Grigorjev was recognized in a street-car by another roentgenologist—a stranger—whose hands bore a like appearance.) Their skin is hard, rough, stiff, and cannot be folded; there are many warty spots, some ulcerated. The most pronounced changes are seen on the fingers, where the sclerosis and ulcerations are particularly extensive and deep. There are only five fingers remaining on the two hands, the others having been previously amputated. There is no hair on the dorsal surfaces of the hands and fingers. The nails are tumefied and opaque, of brownish or yellowish color, and irregular surface.

On opening the skull the dura mater is found to be firmly adherent on almost all surfaces to the bones. The vessels of the

Fig. 1. Section of testicle (fixation in Helly's fluid): Hematoxylin-safran-erythrosin: magnification 170 diameters. 1. Hyalinized seminal tube. 2. Cells of Sertoli in the seminal tube. 3. Group of interstitial cells. No spermatogenetic elements seen.

pia are injected. The arteries at the base of the brain are undergoing sclerotic changes in some places.

Both lungs are fixed by recent adhesions to the chest wall; the parenchyma is flooded by edematous fluid; many bronchopneumonic foci are seen. The aorta is sclerotic, many yellow spots are visible, and calcareous deposits are found. Coronary heart vessels are also sclerotic.

Near the ileocecal valve an ulcerated Peyer's patch is present, evidently a typhoid ulcer in a state of cicatrization. Two more ulcers in a state of desquamation are located higher up. Still higher, some more Peyer's patches are visible, being in a state of tumefaction. This simultaneous presence of different phases of typhoid evolution of Peyer's patches explains the clinical picture—three successive attacks of fever. The lymphatic glands all over the body

appear atrophic, showing no traces of the mobilization usual in typhoid fever.

Microscopic examination of the ulcerations of the skin reveals a typical picture of roentgendermatitis. The epithelium is greatly thickened near the ulcers, and its papillæ elongated, penetrating into the underlying tissues. The dermis is sclerotic and richly infiltrated with numerous plasma cells and polyblasts. Subcutaneous vessels show but a slight swelling of the endothelium.

The structure of the lymph glands is greatly changed. There are no proliferating centers seen; the quantity of lymphocytes is far below normal. The meshes of the reticular tissue are filled up with numerous large rounded or irregular cells, in addition to lymphocytes, which contain in some places two nuclei. These cells are probably of reticular origin. The same elements are present also in the atrophic white pulp of the spleen, where the lymphatic tissue is markedly decreased. In the liver only a few typhoid lymphomata are present.

The changes in the testicles are pronounced. The wall of the seminal tubes is thickened, hyalin, and the lumen is obliterated in most places. Where the lumen is preserved, only a few Sertoli cells are found within; all the spermatogenetic elements are completely absent. Among the tubes numerous groups of interstitial cells are located, containing no crystalloids.

In the spinal cord numerous amylaceous corpuscles are visible. The other organs, including the endocrine system, show no marked changes. Cytologic study, carefully planned, failed, necropsy being performed thirty-six hours after death.

The following findings can be attributed to the chronic exposure to X-rays on the human organism: Ulcerative roentgendermatitis, general atrophy of the lymphatic tissue (which probably has fatal significance in this case), irritation of the reticulo-endothelial system, degenerative changes in the reproductive system (which has no depressing influence on the mental or creative forces), diffuse arteriosclerosis of the large vessels, particularly in the brain and heart, and, finally, obliterative pachymeningitis.

ENDOTHELIOMA OF THE PLEURA: REPORT OF CASE [1]

By FRED W. GAARDE, M.D., Section on Medicine, and CHARLES G. SUTHERLAND, M.B. (Tor.), Section on Roentgenology, Mayo Clinic, ROCHESTER, MINNESOTA

A woman, aged forty-seven, came to the clinic complaining of cough and hemoptysis of eleven months' duration. Except for pneumonia twelve years before, she had been well until August, 1924, when, after a "cold," a non-productive cough continued. After January, 1925, she began having dyspnea on exertion but never while at rest. Hemoptysis commenced in April, 1925, with small quantities, and increased in frequency and amount until some blood was lost every day. Ten pounds in weight was lost in six months. Her voice suggested ulceration of the larynx, but examination failed to reveal any. Paralysis of the vocal cords of the abduction type was thought to be due possibly to a nervous inhibition. A hard, fixed nodule was palpated in the left supraclavicular region. Roentgenographic examination revealed marked increased density over the left base and left periphery to the level of the third rib anteriorly, with a coarse infiltration radiating from the left hilus but not extending to the periphery. This was suspected of being a primary malignant condition with thickened pleura and some fluid (Fig. 1). The patient was too ill for surgical intervention, and returned home. There she was put in a hospital and 1,050 c.c. of sanguineous fluid was withdrawn. The subjective symptoms improved greatly, but the patient died three days later.

Necropsy revealed 1,000 c.c. of sanguineous fluid in the left thorax. A flat tumor, 8 by 10 by 1 cm., was located in the parietal pleura, in the lateral aspect

[1] Received for publication October 28, 1925.

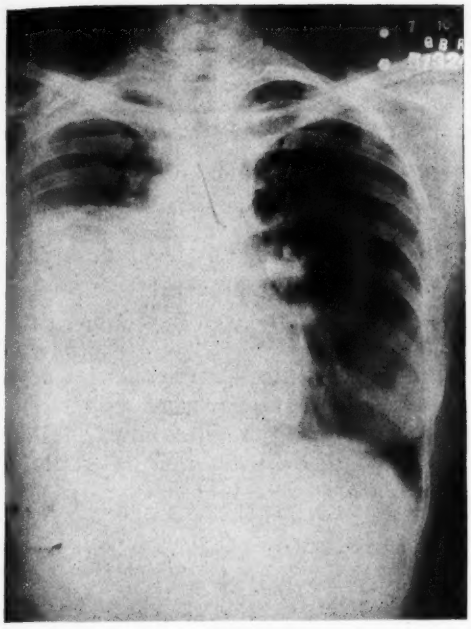

Fig. 1. Marked increased density over the left base and left periphery to the level of the third rib anteriorly. The coarse infiltration radiating from the hilus suggested a primary malignant condition. Necropsy revealed numerous small metastatic areas over the parietal and visceral pleura and around the trachea and large vessels at the upper thoracic aperture.

of the thorax, directly under the shoulder joint. Numerous small metastatic areas were seen over the parietal and visceral pleura and around the trachea and large vessels at the upper thoracic aperture. A few small adhesions were found between the lung and the diaphragm, but there was no apparent infiltration or tumor of the lung. The pericardium, heart and right lung were free from metastasis. The microscopic diagnosis was endothelioma of the pleura.

COMMENT

This case is of interest in that a tentative diagnosis of carcinoma of the lung was made before the roentgenogram was taken on the cardinal findings of hemoptysis, the gradually increasing dyspnea and the marked weakness with loss of weight. Had the patient's condition warranted it, aspiration with the finding of serosanguineous fluid would have completed a general picture, which, in the absence of fever or a definite picture of infection, in a series of cases of malignant conditions of the lung seen at the clinic, always warranted the suspicion of malignancy.

EDITORIAL

TREATMENT OF WHOOPING COUGH

Since Bowditch and Leonard, in 1923 (1), reported favorable results from roentgen treatment of pertussis, it has been used very widely. Large series have been reported, apparently confirming the first results. Now Faber and Struble (2) report that roentgen treatment is without effect in pertussis, that the observed improvement is spontaneous, or at least independent of X-ray. Their series is small, —only 22 treated cases,—but these alternate with an equal number of cases given only antipyrin and no X-ray. They find the two concurrent series running quite parallel courses.

Are we observing in this instance the old fallacy of *post hoc, ergo propter hoc?* Twenty different agents, more or less, in the past five years have been given favorable notice in the treatment of pertussis. Mostly they have fallen into disuse or were never widely used. Vaccine is still thought well of—but not so well as once it was. The fact is that children with pertussis tend to get well, whether anything is done for them or not, and that their progress is anything but regular. Any treatment applied during their convalescence is, therefore, likely to be followed by favorable results, and in some instances the cure will be spectacular. Faber and Struble observed one patient not treated with X-ray (their control group), who suddenly stopped whooping in the second week. Such a case, if treated, would be most "convincing." Also, the laity develops high enthusiasms for new methods of treatment, and where children are the patients their mothers do influence the physician's opinion.

The question is so important that further use of the concurrent control seems justified. Such careful comparison of treated with untreated cases can give a degree of certainty not to be obtained from uncontrolled series, however large.

R. R. Newell, M.D.

REFERENCES

1. Bowditch, H. I., and Leonard, R. D.: Treatment of Pertussis by Roentgen Ray. Boston Med. and Surg. Jour., 188:312, 1923.
2. Faber, H. K., and Struble, H. P.: Does Roentgen Ray Modify the Course of Whooping Cough? Jour. Am. Med. Assn., 85:815, Sept. 12, 1925.

It is proposed to issue an Educational Number of Radiology soon after the opening of the year 1926, containing information relative to the courses in radiology offered by the medical colleges of the country. Practising radiologists who may desire to take post-graduate work will here find what courses are available.

THE ANNUAL MEETING

Presumably all of the members and friends of the Radiological Society of North America who are planning to attend the Eleventh Annual Meeting, in Cleveland, from Monday, December 7, to Friday, December 11, inclusive, have already perfected their plans, if they are not already actually on the way. The Scientific Sessions, the Commercial Exhibits, the business meetings, and banquet are all to be held at the Hotel Cleveland, on the Public Square, chosen as the headquarters.

A splendid program has been prepared,

the exhibitors of apparatus and equipment have perfected their plans, and altogether this promises to be a most successful meeting. There are excellent reasons why the ladies should attend, also. You who heard Dr. W. J. Mayo's address at Rochester, two years ago, will remember that he complimented the gentlemen on the ladies who accompanied them, and the ladies for their perspicacity in coming.

ABSTRACTS OF CURRENT LITERATURE

INDEX TO ABSTRACTS IN THIS ISSUE

Cancer.—The surgical treatment of cancer is based on the fact that cancer originates as a solitary neoplasm, and if operation is performed while the disease is still confined to a single area, the results may be very satisfactory.

Certain cases of cancer seem to be hopeless from the beginning, and surgery, or any other method of treatment, apparently does not influence the progress of the neoplasm.

In certain cases in which the condition seems to be extensive and to involve surrounding structures, there may still be a chance of cure by complete eradication.

The most important development in our knowledge of cancer in recent years has been Broders' gradation of the malignancy according to the cell differentiation, which permits a fairly accurate prognosis, and prevents operating on a certain group of patients for whom treatment is of no avail.

It is not the writer's purpose to make great claims for the surgical treatment of cancer, yet he does contend that surgery has done more for persons suffering from this disease than all other methods of treatment combined. Although the results are somewhat discouraging, he believes that every patient who has a malignant growth should be given the opportunity of whatever treatment offers the best results. It is not right to consider cases hopeless without first making a careful estimate of the grade of the malignancy and of all other factors.

Operations on patients whose condition can be shown to be hopeless are a discredit to surgery. Even palliative operations, if the growth can not be removed under ordinary circumstances, should not be undertaken.

W. W. WASSON, M.D.

The Surgical Treatment of Cancer. E. Starr Judd. Jour. Am. Med. Assn., Jan. 3, 1925, p. 10.

Temporary roentgen-ray sterilization.—This is a very conservative paper on the indications for the administration of a temporary sterilization dose. As we are not sure whether the sterilization will be temporary only and as there is no definite opinion as yet in regard to the possible injury to the future embryo, this therapeutic procedure should be limited to the following cases: (1) A later conception must be almost impossible considering the present disease; (2) The present disease must endanger the life of the patient and operative therapy be impossible; (3) If on account of the present disease the generative function shall be stopped permanently and a full sterilization dose cannot be given for some reason or other. Great caution is advised in X-ray treatment of ovarian dysfunctions in young girls.

E. A. POHLE, M.D.

Temporary Roentgen Sterilization and its Indication. H. Borell. Strahlentherapie, 1925, Vol. 20, 1, p. 89.

"Leather-bottle stomach."—Leather-bottle stomach has been called by many different names: (1) Leather-bottle stomach; (2) Fibromatosis of stomach; (3) Scirrhous carcinoma of stomach; (4) Linitis plastica; (5) Cirrhosis of stomach; (6) Fibroid induration of stomach. Observations recorded up to the present are not sufficient to decide its pathological nature.

Two cases are cited, both having the same macroscopic appearance, but different microscopic pictures. One was colloid carcinoma, the other later malignant. The name "leather-bottle stomach," then, cannot be used to connote any particular histological structure and should be employed only to denote a certain macroscopic appearance. The relation of these groups to each other is readily seen in the following tabular presentation:

Fibromatosis of stomach	Local	
	Diffuse	Leather-bottle stomach
Carcinoma of stomach	Diffuse	
	Local	

Examples are shown of all types, two of the author's cases being of the local fibromatosis type. Radiographically these cases present a picture similar to carcinoma and are probably indistinguishable from carcinoma except by microscopic examination. It is believed that the process is a progressive one, running on eventually into the diffuse fibrosis type. Syphilis, tuberculosis, neoplastic growth and inflammatory fibrosis are all discussed and discarded as possible etiological agents. The most probable solution of the problem seems to be that the condition is primary and neoplastic, a fibromatosis upon which is subsequently engrafted an inflammatory element.

Summary.—Leather-bottle stomach is thus seen to be neither a clinical nor a pathological entity and is a name that should be abandoned as serving no useful purpose. The controversy as to its nature, whether simple or malignant, is also settled, since it may be either the one or the other. "Diffuse fibromatosis" or "diffuse carcinomatosis" are suitable names which aptly designate the two conditions included by the original term.

L. R. SANTE, M.D.

Some Observations on the Condition Sometimes Called "Leather-bottle Stomach." Stanley Wyard. Surg., Gynec. and Obst., April, 1925, p. 449.

Influence of radio-activity on metabolism in cells.—In this article, the author presents the results of twenty years' research on the influence of radium radiation on the metabolism in cells. He points out that the radio-activity of the soil, water, and air has a very marked stimulating effect on all oxydizing processes in the living organism. Investigations have, *e.g.*, shown that the air in the neighborhood of volcanoes (Vesuvio, Naples, Italy) is several times as radio-active as the air in other parts of the country. The unusual fertility and rapid growth of plants is explained by this fact. The alpha rays of radium have the strongest effect, next are the beta rays, while gamma rays are less absorbed.

By giving radio-active baths saturated with oxygen the respiratory metabolism in man was definitely increased. As potassium (K) is the only element in the organism emitting beta rays of high velocity, it is said to have an important rôle in life. The ash of the pancreas of the normal individual contains mostly phosphorus and potassium ions, the total amount of which was reduced to 50 per cent in a patient who died from diabetes. The carcinoma and sarcoma tumors are also very rich in potassium. The author believes that the emission of beta rays from this element is responsible for the rapid growth of these tumors. Experiments have proved that it is possible to increase plant growth up to 120 per cent by using beta radiation in a patented process discovered by Stocklasa.

E. A. POHLE, M.D.

The Influence of Radio-activity on the Metabolism in Cells of Animals and Plants. J. Stocklasa. Deutsche med. Wchnschr., 1925, No. 26, p. 1057.

Malignant tumors.—Conditions governing growth of cancer are as precise as those regulating normal tissue. Genesis of cancer will come only after a knowledge of factors producing cell-proliferation, differentiation and de-differentiation. Rous' extract is the most important advance in cancer research of recent years. Rous' sarcoma developed *in vitro* shows cells of various types. Pure cultures of these cells show only macrophages to be malignant. The sarcoma macrophage is short-lived and, in dying, reproduces the Rous substance, thus starting an endless process. This process is probably common to all sarcoma cells.

The addition of coal tar to pure cultures of fibroblasts and macrophages does not produce malignant changes. Its mode of action differs from Rous' substance. Embryonic pulp inoculated under skin develops malignant tumors after tar injected intravenously. Certain substances in the blood produced by bacteria and helminths, or resulting from X-ray burns, probably

act as tar, producing spontaneous tumors. Irritation renders Rous' extract more active.

All chickens injected with pure Rous' extract showed tumor growth. Making certain dilutions showed that resistance to tumor growth varied in different animals. This resistance is permanent and constant. Rous' sarcoma, when removed early, does not leave animal immune to future injections. Chief cause of susceptibility to Rous' substance was age, the young proving more susceptible than the old. Mixture of Rous' extract with serum from immune animals and old animals shows lower percentage of tumor determination. Growth of fibroblasts in serum of adult gradually decreases and finally stops; in serum of embryonic tissue, growth is unlimited. Serum contains inhibiting and stimulating properties to cell growth, the former predominating in old age, the latter in youth.

S. C. Barrow, M.D.

Mechanism of the Formation and Growth of Malignant Tumors. Alexis Carrel. Annals of Surgery, July, 1925, p. 1.

Physico-chemical effect of roentgen rays.—Microchemical investigations demonstrated the abundant presence of potassium (K) in the neighborhood of the roots of hairs. The change of the potassium content before and after the exposure of the skin to an epilation dose was observed in rats, guinea pigs, and a dog. The potassium disappeared almost completely after the treatment; at the same time, the distribution of calcium was definitely changed from an even network to a more concentrated nodular arrangement. These changes may be explained by Donnans' theory (disturbance of the equilibrium of membranes).

E. A. Pohle, M.D.

Physico-chemical Effect of Roentgen Rays on the Organism. G. D. Lieber. Strahlentherapie, 1925, Vol. 20, 1, p. 93.

The systemic effect of roentgen rays.—This is a very interesting critical review of the investigations on the systemic or general effect of X-rays. As this paper covers over sixty pages, it is not possible to abstract it in detail, but it is warmly recommended for study. In his summary the author notes that all organs do respond in some way to radiation and that this reaction can be detected by clinical methods. Two questions come up as a result of his studies of the literature: (1) What is the mechanism of the X-ray effect and is there one factor responsible for all the changes caused by radiation? (2) Is the therapeutic effect to be explained by a local process or is the general effect on the system the explanation of the result? As to the first question, he believes that the etiology of the X-ray effect is to be sought in the influence on the cells primarily. The second question is much more difficult to answer; as a matter of fact, no definite proof for the one or the other theory exists. For a good end-result, however, it seems wise to consider both local and systemic action of roentgen rays.

E. A. Pohle, M.D.

The Systemic Effect of Roentgen Rays; A Critical Review. B. Kuhlmann. Strahlentherapie, 1925, Vol. 19, No. 5, p. 817.

Injuries to the foot.—The astragalus is most frequently broken at its weakest point, the neck. The os calcis is fractured by a fall on the sole of the foot as well as by a powerful contraction of the gastrocnemius muscle and tension of the tendo achillis. The variety of fracture resulting is a large posterior heel piece or a general crushing of the central or anterior two-thirds.

The metatarsal bones are injured by direct violence. The first, although the strongest, is the most frequently broken because it carries a large percentage of the body weight. The fifth is next in frequency owing to its exposed position.

The phalanges are usually broken from direct violence.

L. R. Sante, M.D.

Fractures of the Foot. Leo Dretzka. Surg., Gynec. and Obst., April, 1925, p. 522.

Carcinoma of the cervix. — It is difficult, indeed, to compare the results of radiation treatment of carcinoma of the cervix obtained by various clinics. The introduction and general use of a well defined unit (R-unit) or one roentgen, will, therefore, bring us a step forward, not only in arriving at useful statistics but also in controlling our dose. The skin unit dose (H.E.D.) of Seitz-Wintz is too much subjected to personal errors, as it has been shown that this H.E.D., or erythema dose, varies from 285 to 1,120 R in several clinics. The medium dose of 600 R is suggested as an average full dose to be administered. The author has recalculated the X-ray and radium doses given to his cases of carcinoma of the cervix in 1918 to 1925 on the basis of these 600 R as a unit, especially considering the so-called critical zones, *i.e.*, parts which cannot be overdosed without danger (ureter, bladder, rectum). He comes to certain conclusions as to the best treatment of these patients. The classification used is: Group 1, early (operable); Group 2, farther advanced, operability doubtful; Group 3, inoperable but with growth localized in the pelvis; Group 4. inoperable and metastasized beyond the pelvis. The best procedure seems to be the

combined use of radium and X-rays. Although his method is not a "cure for cancer," it is justifiable to state that with a certain system, good results can be obtained in radiation treatment of carcinoma of the cervix. There is no reason for pessimism.

E. A. POHLE, M.D.

The Results of Radiation Treatment for Carcinoma of the Cervix; the Doses Measured in R Units in the So-called Critical Zones. W. Lahm. Strahlentherapie, 1925, Vol. 20, 1, p. 1.

Uterine fibroids.—The author gives the following as his objections to radiation and advises it only in cases where there is a grave constitutional contra-indication to operation. Radiation objectionable because: 1. Length of time consumed makes it expensive. 2. There are more risks, more complications and more sequelæ than in operation. 3. The risk of destroying function of ovaries. 4. Toxicity caused by radiation objectionable. 5. Produces distressing symptoms not easily relieved. 6. Deformity of skin in the way of discoloration objectionable. 7. Future of tissue left behind unknown. 8. Blood does not return to normal as after operation. 9. Blood changes after radiation not understood. 10. Treatment does not appeal to him.

The facts that his mortality is 2.1 per cent, that the ovaries are left behind and that there is no tumor residuum, are sufficient arguments for operation. Experience shows fibroids increase rather than decrease after menopause.

S. C. BARROW, M.D.

Treatment of Uterine Fibroids. John B. Deaver. Annals of Surgery, September, 1925, p. 486.

To the radiotherapist who has treated these cases in the hundreds, the above seems to be without argument and illogical.—S. C. B.

Stimulating effect of radiation.—The biological fundamental law (Arndt-Schultz) which states that small stimuli promote, strong stimuli inhibit or stop, the vital processes in cells has been widely used in biological ray research. A review of recently published papers, however, does not furnish enough clear evidence to warrant this assumption. The author has, therefore, conducted a series of experiments under the following criteria: (1) Isolated cells were used; (2) The presence of any other effect except radiation was carefully avoided; (3) The number of tests was very high, to rule out the error always connected with the interpretation of results based on low figures.

The ovuli of *Ascaris Megalocephala*, taken from the uterus of the female animal, were placed on a slide, irradiated, and then kept in the incubator. The number of eggs undergoing mitosis after exposure to ultra-violet rays, roentgen rays, and radium were compared with untreated controls. It appeared that only the slides exposed to X-rays showed a small but definite stimulating effect, while both ultra-violet rays and radium in small doses proved to give negative results. The author, therefore, concludes that the stimulating effect of X-rays on cells cannot be denied, although general adoption of the Arndt-Schultz law is not indicated at this time. On the other hand, it might be quite possible that the stimulating effect on the whole organ is true.

E. A. POHLE, M.D.

Biological Experiments on the Question of the Stimulating Effect of Radiation. J. Seide. Deutsche med. Wchnschr., 1925, No. 29, p. 1186.

Ureteral strictures.—Strictures of the ureter may be divided into congenital and benign varieties. Congenital strictures are well known and have long been recognized. The present paper is devoted particularly to the acquired type.

The anatomy of the ureter is briefly reviewed. The ureters are musculomembraneous tubes, one on each side of the body, extending from the pelvis of the kidneys to the bladder just beyond the outer edges of the transverse processes. Several points of normal constriction are present in the ureter; at the uretero-pelvic junction, as the ureter crosses the iliac vessels, and at the point of entrance of the ureter into the bladder. On the right side it passes beneath the cecum; this close relationship is especially emphasized. Definite peristalsis has been demonstrated in the ureter; reverse peristalsis has also been shown. Stricture of the ureter is about as prevalent in women as in men and occurs with very little percentage of variation at all ages over twenty years. No cases were seen younger than twenty years of age. Cause of stricture may be due to trauma, passing of stone and after childbirth and operative procedure, infection by destruction of the normal structures, and by direct extension of disease processes.

The most efficient aid in diagnosis is obtained by injection of opaque material and X-ray examination.

1. Stricture of the ureter is a definite pathological entity. 2. It occurs mostly between twenty and forty years of age. 3. It constitutes about 10 per cent of the upper urinary lesions. 4. It is not purely a focal infection, but due to

extension of disease by continuity as well. 5. It is more commonly a gonorrheal process than is generally supposed and its pathology is somewhat similar to urethral lesions. 6. Symptoms are largely local. 7. Diagnosis may be made certain by history and X-ray, aided by ureteral bougie. 8. Treatment limited to dilatation.

L. R. SANTE, M.D.

Stricture of the Ureter. Winfield S. Pugh. Ann. Surg., April, 1925, p. 839.

Cancer of the breast.—An analysis of ninety-two cases taken from various hospitals and operated on by various surgeons, shows decided improvement in end-results in cases receiving post-operative radiation and a further improvement in cases receiving both pre- and post-operative radiation. Taking all cases, those receiving pre- and post-operative treatment, 52 per cent were alive and well for three years. Of those receiving only post-operative treatment, 39 per cent were well three years. Of those receiving no radiation, 24 per cent were well. Rejecting all cases excepting the moderately and highly malignant types, the pre- and post-operative radiated cases showed 46 per cent well for three years. The post-operative radiated cases showed 33 per cent, while the cases treated with surgery showed only 21 per cent.

From this analysis the authors conclude pre- and post-operative radiation to be justifiable and the loss of time more than offset by the results obtained. Histological evidence at hand, with careful clinical analysis, confirms their belief in the efficacy of the combined treatment. Careful technic and proper dosage is urged, which will largely determine the end-result.

S. C. BARROW, M.D.

An Evaluation of Pre-operative and Post-operative Radiation in the Treatment of Mammary Carcinoma. Burton J. Lee and Ralph E. Herendeen. Annals of Surgery, September, 1925, p. 404.

INDEX TO VOLUME V
